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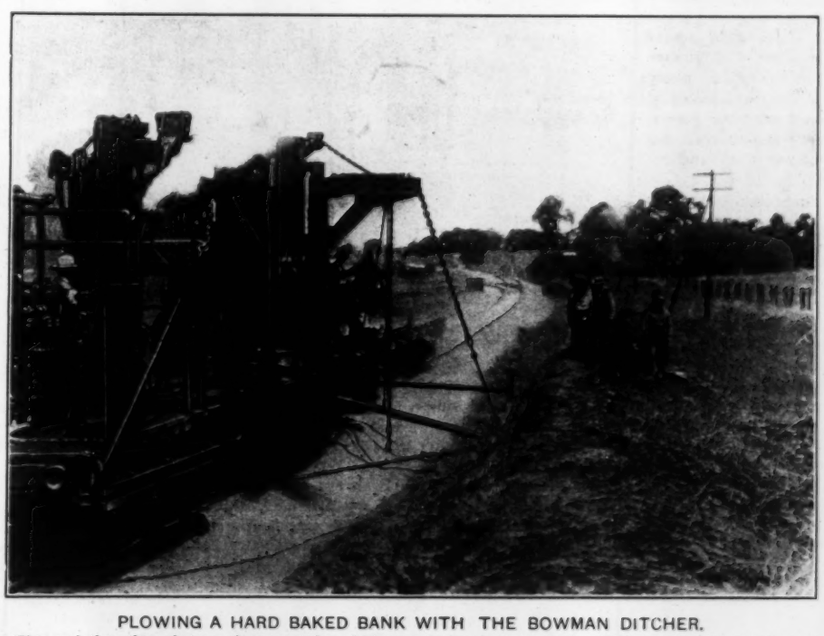
A Railway Ditching Machine for Small Cuts and Fills.*

The machine shown in operation in the accompanying photographs was designed for widening and cleaning the ditches in small railway cuts. On the Southern Pacific Ry. where it is in use, there are many miles of single track through rolling country with a great number of small cuts and fills. The ditcher is used in widening these cuts, where double-tracking is contemplated, or in clearing existing ditches in earth cuts and where a smooth, even slope is desired. This work is not of such magnitude as to warrant the use of a steam shovel, but can be done by the ditching machine more economically than by manual labor.



PLOWING A HARD BAKED BANK WITH THE BOWMAN DITCHER.

(This and the other photographs were taken during preliminary tests of the ditcher and give an idea of the nature of the country where it is used.)

The general construction of the ditcher is shown in Fig. 2. The car body, similar to that of an ordinary flatcar, carries the four pneumatic cranes which handle the plows, slopers and scoops. There are two cranes on each side of the car and the operations of plowing, filling the scoops, etc., may be carried on on both sides of the right-of-way at once. The various operations are performed by mounting the respective implements in position for action and then towing the ditcher with the locomotive required constantly in attendance.

COMPRESSED-AIR EQUIPMENT—The function of the cranes is to raise and dump the scoops and to assist in guiding the plow and sloper. The cylinders of the pneumatic hoists are in the center of the car between the cranes, as shown in Fig. 2. For each crane there is a large cylinder to operate the main hoist and a smaller one for the auxiliary hoist used in dumping the scoops. The compressed air is supplied by three compressors of the air-brake type, which, together with the two cylindrical air reservoirs, are mounted on the forward part of the car. Steam for the compressors is supplied by the boiler of the attendant locomotive.

The operation of the various hoists is controlled by one man at the air-distributing manifold shown in the plant view, Fig. 2. A separate valve is provided at the manifold for each of the eight crane cylinders and the two small cylinders used for guiding the plow. These guiding cylinders are under the car body at the rear and may be seen at the right of the plan.

PLOW.—The plow is shown in operation on this page. It is hung from the main chain of the rear crane, which controls its working depth, and its line of action is controlled by the guiding cylinder acting through a steel pole attached at the rear of the plow-beam. A second steel pole projects from a fixed bracket on the side of the car and is attached to the plow-beam near its forward end. This pole has a universal joint at the bracket so that it can follow any vertical or horizontal movement of the plow. A pulling cable passes from the forward end of the plow-beam to its fastening on the forward corner of the car.

The pole projecting from the bracket on the car body acts as a distance rod or strut to hold the plow to its course against the lateral component of the pull in the cable. The outer end of the pole serves as the fulcrum about which the plow turns under the action of the guiding pole. A considerable range of working distance from the track is attainable with one length of pole by varying the length of the pulling cable, but the pole is made in two parts, one telescoping within the other so that its effective length may be changed to permit a wider range of working distances. The length of the pole is kept from changing while in use by bolts passed through corresponding holes in the sleeve and inner pole.

The heaviest plow obtainable in the market was first tried but proved unequal to the work, and it became necessary to specially construct a heavier plow. The details of the special plow are shown in Fig. 3. The principal member is a flat laminated plate 4 ft. long with a cutting height, or depth, of 20 ins. below the beam. It is built up of three layers of ½-in. boiler plate riveted together. This member does the work of both the share and land-side in the usual form of plow. The front edge is beveled at an angle of 60° with the direction of motion and curves down and forward to a point at the bottom. The slip point is of tool steel about 2 ft. long with 1 by 3-in. cross section and it is held in its socket in the front lower edge of the main plate by four ⅞-in. bolts. The mold board is a single sheet of ¾-in. boiler plate riveted to the laminated plate at about the middle of its length. The back end where it flares away from the land-side is supported by a riveted brace.

The upper portion of the laminated plate extends up between the two 10-in. channels which form the beam, to which it is made fast by ⅞-in. rivets. The beam is a little more than 7½ ft. long and is flush with the main plow plate at its rear end. At this end, a 4 by 1½-in. steel bar projects 2 ft. above the plow beam and has three holes spaced 6 ins. apart, in any one of which the guiding pole may be attached. The lug, or ring, for the crane chain is riveted to the beam at a point above the forward edge of the plow, and the lug to which the fulcrum pole is fastened is 10 ins. from the forward end of the beam. The pulling cable is fastened to the ring at the extreme forward end of the beam.

A combination disk plow and sloper plate for inclined banks was used in the tests of the ditcher, but the disks bent as though of paper and its use was abandoned in heavy material. This plow and the attached sloper plate may be seen, in Fig. 6, standing on end on the floor of the car between the two cranes. The deformation of some of the disks is evident in the illustration.

SCOOPS.—The material loosened by the plows is collected by the scoops as shown in Fig. 6. There are two scoops for each side of the car, one being handled by each of the four cranes, and each scoop has a capacity of 4 cu. yds. They are

*From information furnished by Henry V. Miller, 314 P Street, Sacramento, Cal.

so hung that when lifted, after having been drawn through the loose material and loaded, they will tilt backward, and this tilting is restricted by chains connecting the bale of each scoop to its back wall. The loaded scoops are hoisted by the main crane cylinders through a single chain attached to the bale. The dumping chain, fastened to the back of the scoop, is operated by the smaller auxiliary hoist.

The scoops are dragged through the material loosened by the plow by chains leading to the pulling beam. There are two chains for each scoop, attached one on each side at the front near the bottom. The pulling beam is shown in the photographs and in Fig. 2. It is built up of two 10-in. channels back to back with the long webs horizontal and spaced a few inches apart so that the coupling links at the ends of the pulling chains can be slipped between them. The chains are coupled to the beam by vertical pins passed through holes in the channels and through the coupling link between. The beam extends out about 10¾ ft. from the side of the car body and is provided with a number of coupler holes so that the scoop chains can be attached at any point as desired in working at different distances from the track.

The beam has a pin joint, or hinge, at its junction with the car body and the tensional component of the pulling strain is taken by a diagonal tie rod from the outer end of the beam to the forward corner of the car. When not in use, the tie rod is disconnected and the beam swung in forward against the car body to the position shown in Fig. 1. A second tie rod passes from the end of the beam to the top of the rectangular frame above the manifold and supports the beam's weight.

SLOPER.—The sloper is pulled by this same beam and is attached to it by a cable and leading chain, as shown in Fig. 4. It consists simply of a flat laminated steel plate about 4 ft. square to which is riveted a curved plate flaring away from it at the rear to act like the mold board of a plow. No guiding pole is used with the sloper, but there are two fulcrum poles universally jointed to their bracket on the car body and attached to the sloper, as shown in the end elevation, Fig. 2. By changing the relative lengths of these poles, it is possible to change the angle of the bank the sloper cuts. As shown in Fig. 4, the working position of the sloper is controlled by the main chain of the rear crane, from which it is hung.

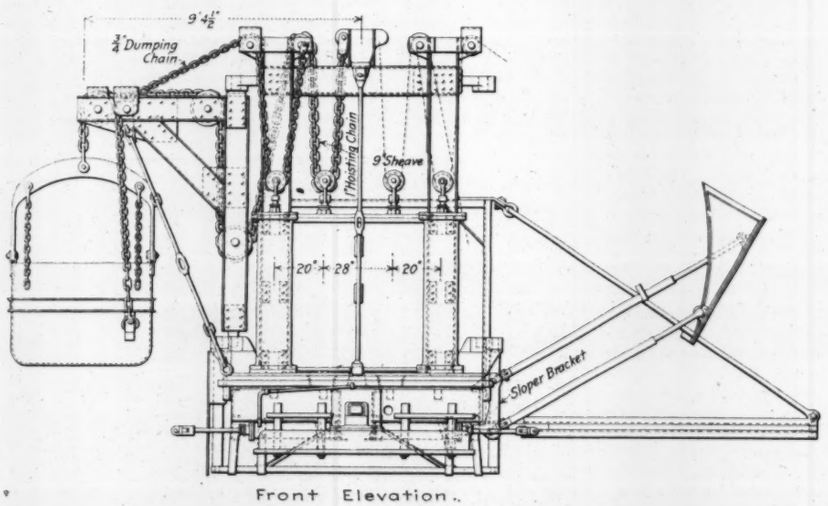
SPREADER.—The spreader is shown in Fig. 2 (plan) in its working position, swung out to an angle of about 40° with the direction of motion. It is held in this position by a bracing pole extending out from the frame of the car. When not in use, the pole is removed and the spreader can be swung back on its hinge until flat against the car body, as shown in Figs. 1 and 4. The spreader is used in distributing dumped material to give an even surface to fills alongside the track.

OPERATION AND RESULTS.—In using the ditcher, the first operation is to break up the ground with the plow. Then the scoops are put in position and pulled through the loose material by means of the locomotive. The filled scoops are lifted by the pneumatic cranes and the locomotive tows the ditcher to the dumping place. When necessary, the dumped material is leveled off by the spreader. The ditcher is then returned to the cut and the final slope of bank is obtained with the sloper. The scoops may again be necessary.

At first thought it would appear to be clumsy and uneconomical to remove the excavated material in this way in comparatively small quantities, but consideration of the nature of the country in which the ditcher is used will show it to be well suited for the special conditions found there. Cuts of any great length are very rare and, in the majority of cases, a travel of only from 500 to 1,200 ft. is required from cut to dump, and the yardage to be removed from any one cut is usually so small that not many trips are necessary. The excavated material can be dumped at such a distance from the tracks as to require generally no further attention, as can be seen from Fig. 5.

During the preliminary tests of the ditcher it was tried out on the material of the California foot hills in midsummer when the soil was baked to nearly the consistency of hardpan. Under these conditions, and when the operations of plowing, sloping, hauling and spreading were all required, a total of 360 cu. yds. was removed in six hours. This was done in 30 loads, with an average travel of 1,200 ft. from cut to dump.

The ditcher was designed by Mr. Ben. Bowman, of Springfield, Mo., who has obtained patents on all of its essential features. It was built at the Sacramento shops of the Southern Pacific Ry. Co.



Front Elevation.

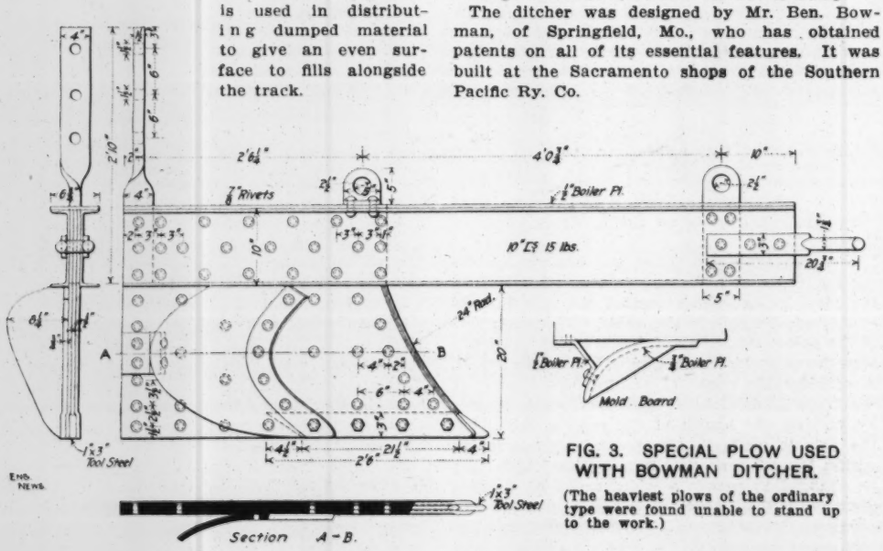


FIG. 3. SPECIAL PLOW USED WITH BOWMAN DITCHER.

(The heaviest plows of the ordinary type were found unable to stand up to the work.)

Barometric and Temperature Conditions at the Time of Dust-Explosions in Appalachian Coal Mines.*

By N. H. MANNAKEE,† M. Am. Inst. M. E.

Since the publication of the paper of Mr. Scholz, "The Effect of Humidity on Mine Explosions,"‡ I have undertaken a study of the meager available data of barometric and temperature conditions at times of mine explosions, and have arranged these data in a manner which may be of interest to other students of mine explosions. This study covers the period from 1898 to 1909, during which an ever-increasing percentage of collieries has been ventilated by fans giving air currents of high efficiency. This general improvement in ventilation throughout the Appalachian field has undoubtedly brought about a condition which is annually the cause, or a very important attendant, of the high percentage of fatalities in mine explosions.

There is a widespread opinion that this condition exists from November 1 to March 31; but it is more likely that they have a much wider range, which varies from year to year. If mine explosions are influenced by a lack of moisture in the mines, certainly it may be expected that the influence will be felt at times when the moisture falls below the safety point, and this relative condition may appear from year to year in the months of September and October, and April and May. Since the carrying power of air for water vapor diminishes as the temperature falls, there will be experienced, in general, a reduction of moisture in the mines the moment the intake temperature falls below that of the return air. This robbing of a mine of moisture is dangerous if carried to a certain point, and this point varies under different conditions in the same locality; but the exact point at which it should be placed remains to be determined. The presence of dust in a mine, even in one portion only, has repeatedly been the cause of an explosion; and the violence of the explosion is determined by the extent of the dusty territory.

I believe the real solution of the problem is, so to control the temperature and humidity of the mine air that a dust explosion will be impossible. I regard such control as practicable.

BAROMETRIC AND TEMPERATURE CONDITIONS.—A careful study of the conditions can only be made after the systematic collection of data. The data herewith presented are not exact; but, so far as I can ascertain, they are sufficiently close to the truth to justify the arguments drawn therefrom. Some of them are not new, but are presented in order to make comparisons which I have not seen elsewhere. They are derived from a complete list of mine explosions occurring in the Appalachian coal fields from 1898 to 1909, published by Mr. H. N. Eavenson,§ and from certain other data collected personally to bring it to date. Only those explosions are considered which were caused by dust or gas, or both, and in which five or more fatalities occurred.

Table I. shows the barometric condition at the time of explosions. The daily weather maps, issued by the

*Abstract of a paper presented at the Spokane meeting of the American Institute of Mining Engineers, September, 1909.

†Williamson, W. Va.

‡"Transactions," American Institute of Mining Engineers, Vol. xxxix, pp. 328 to 336 (1909).

§"Bulletin" of the American Institute of Mining Engineers, June, 1909, pp. 567 to 578. Eng. News, Aug. 5, 1909, p. 158.

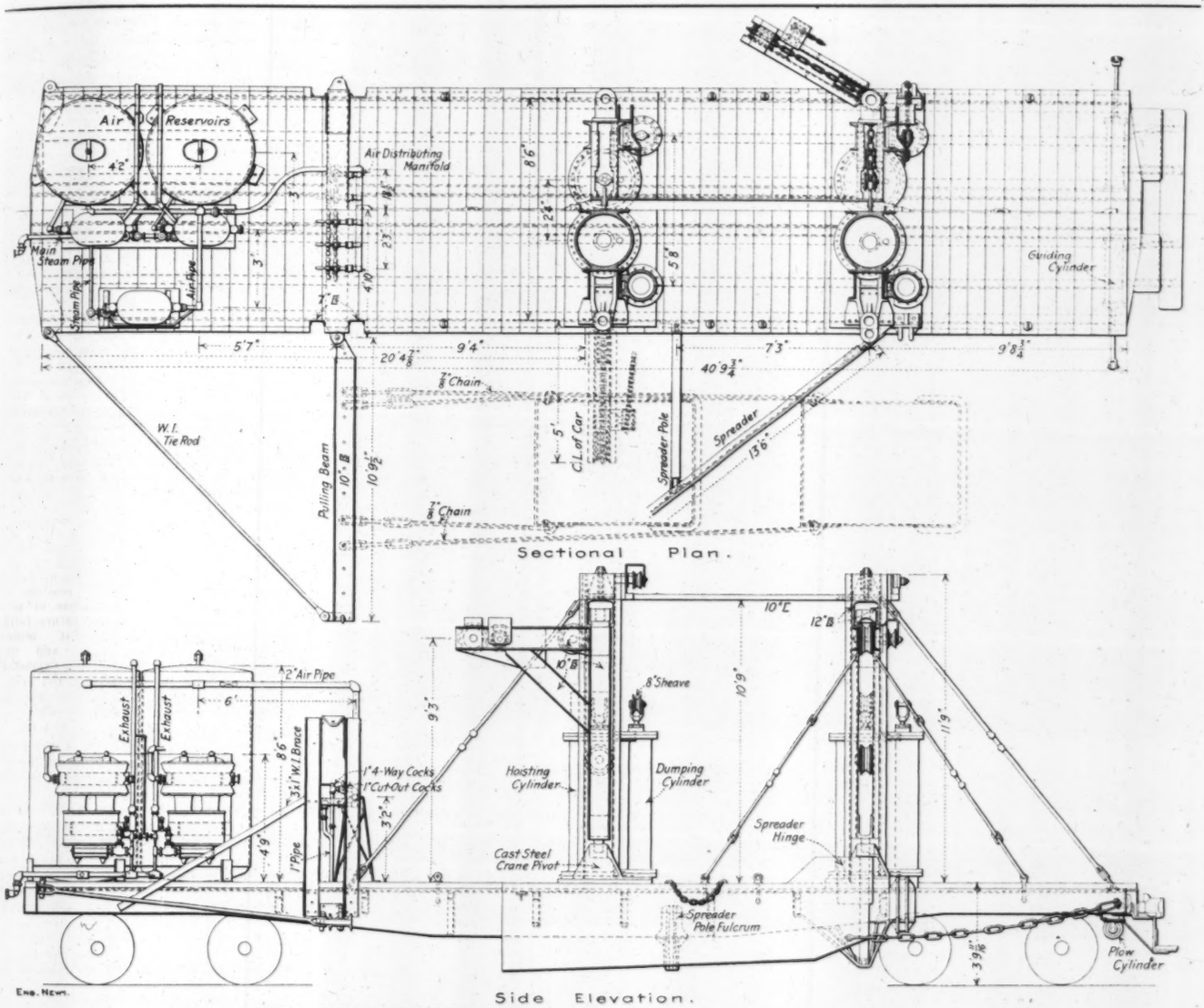


FIG. 2. RAILWAY DITCHING MACHINE FOR SOUTHERN PACIFIC RY.
(Designed by Ben Bowman, Springfield, Mo.)

United States Weather Bureau, show lines of equal barometric pressure; and certain points where explosions occurred were located in high-pressure or low-pressure areas, or occupied a mean between high and low pressure. Table I. shows that, out of 49 explosions for which data were available, 23, or 46.94%, took place in high-pressure areas. The number of explosions which occurred in mean-pressure areas was 18 out of 49, or 36.73%. The number of explosions occurring in low-pressure areas was 8 out of 49, or 16.33%. This indicates that the pressure is generally likely to be high at the time of an explosion. Dry air is heavier than damp air, hence dry air indicates high barometer.

Table II. shows the number and percentage of explosions at certain temperatures and the number and per cent. of fatalities.

Particular attention should be given to the explosions occurring above 60° F. Here are 5 explosions out of 52, or 9.61%, and in these explosions 314 out of a total of 2,126 fatalities, or 14.77%. It is my opinion that

TABLE I.—BAROMETRIC CONDITION AT TIMES OF EXPLOSION.

Explosions.	No.	Per cent.
In high-pressure areas	23	46.94
In mean-pressure areas	18	36.73
In low-pressure areas	8	16.33
Total	49	100.00

TABLE II.—EXPLOSIONS AT OR BELOW VARIOUS TEMPERATURES, AND NUMBER OF FATALITIES REDUCED TO PERCENTAGE.

External temperature at or below.	No.	Per cent.	No. of fatalities.	Per cent.	No. of fatalities per explosion.
32° F.	29	55.77	1,539	72.39	53.07
40° F.	36	69.23	1,658	77.98	46.06
50° F.	41	78.85	1,721	80.95	41.9
60° F.	47	90.39	1,812	85.23	38.6
Above 60° F.	5	9.61	314	14.77	62.8
Total explosions considered	52	100.00	2,126	100.00	40.9

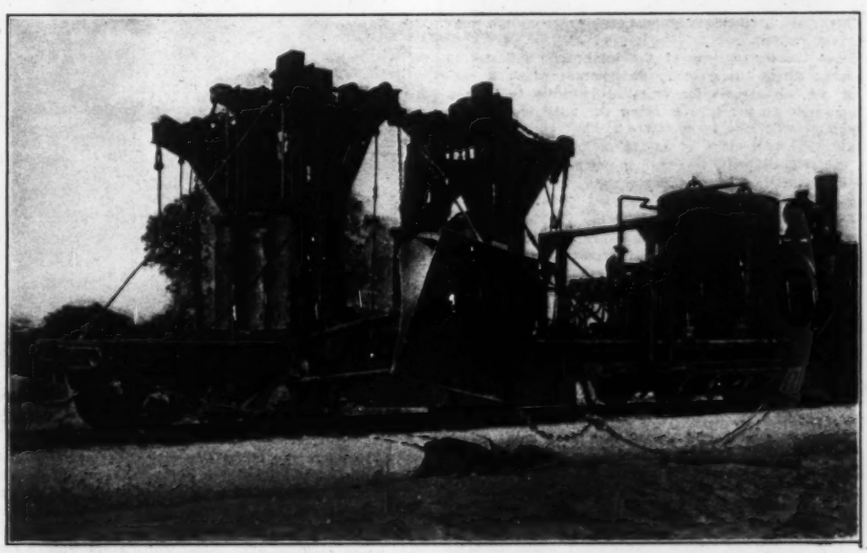
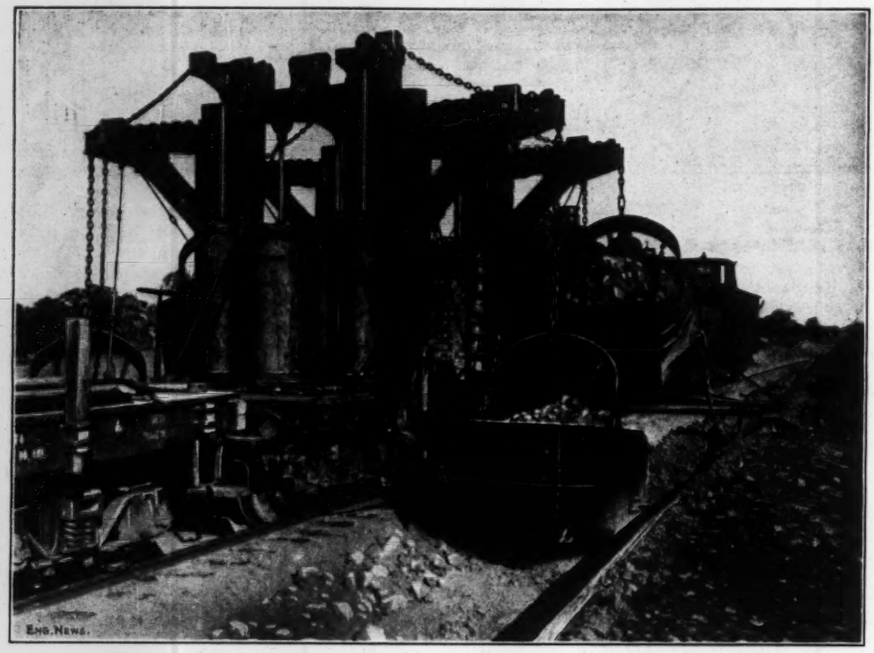


FIG. 4. BOWMAN DITCHER WITH SLOPER MOUNTED READY FOR USE.
(This device is used for giving the final slope to the banks of small cuts.)

these five explosions, occurring above 60° F., were strictly gas explosions. There is also a certain percentage of the explosions which occurred at 60°F., and below, which are distinctly gas explosions and in which dust plays no important part. Table II. is, therefore, not a fair *resume* of explosions which have in whole or in part been caused by the presence of dust.

HUMIDITY OR MOISTURE CONDITIONS.—A table in the paper of Mr. H. N. Eavenson* shows that during the winter months water is removed from the mines by the ventilating current at the rate of from 2,777 to 16,694 gals. per 24 hours, and that in the summer months it is deposited in the same mines at the rate of from 2,978 to 8,088 gals. per 24 hours. There is a gradual passage, step by step, from the condition of robbing the mines of moisture in winter to the deposition of moisture in summer; and there is a time at which the ventilating current neither gives nor takes moisture in traveling through the mine. I believe that this balanced condition occurs between the last of March and the middle of May, alternating between short periods when the mines are robbed of moisture and periods when they receive moisture from the ventilating current. These fluctuations occur until about the middle of May, after which the summer condition very likely prevails until the middle of September, when we again experience the variation between excess and scarcity of moisture. Then, in the last part of October or the early part of November, the winter condition is installed again, and the mines give up their daily quota of water to the ventilating current.



LOADING THE SCOOPS OF THE BOW MAN DITCHER WITH MATERIAL LOOSENED BY THE PLOW.

Since the temperature of the intake air indicates to a large extent the quantity of moisture which it carries, we can assume for practical purposes that when the outside temperature is below the mine temperature the mine will give up moisture to the ventilating current. The percentage of saturation of the outside air in winter is evidently less than in summer, and the same condition exists in regard to the mine air, but is not so pronounced. And since the carrying power of the air diminishes as the temperature falls, it would be expected that the quantity of moisture carried out of a mine in 24 hours will increase in greater ratio than the difference in temperature between the intake and the effluent air.

On the other hand, increase of temperature indicates a higher percentage of saturation, and higher temperature indicates higher carrying power for moisture. Thus it would seem that when the temperature of the intake air is 5° higher than the temperature of the effluent air, a certain quantity of water would be deposited in the mine, and when the temperature of the intake air is 5° lower than that of the effluent air a much larger quantity of water would be carried out of the mine. It naturally follows that at those times of the year when the outside temperature falls several degrees below the inside temperature the mines will become drier. The greater this difference in temperature of intake air and effluent air, and the longer this condition exists, the more pronounced will become this dry condition. All of those mines which become dusty and which are liable to be dangerous on this account have a certain safety point which lies somewhere between the extremes pointed out above. There are no definite records to show at what temperature certain mines begin to become dry, or when they will become wet. Yet these two questions are on the very threshold of the inquiry.

So long as it is not known at just what point of relative dryness the condition of a mine becomes dangerous, we shall continue to follow along the same old rut, or have the law-makers force on all mines rigid laws which are mere guesses at the real remedy.

Possibly this very winter direful explosions may occur close together, and create such a popular storm of sympathetic but ignorant indignation that some very drastic though futile mine laws may be enacted. To prevent such hasty action it is necessary to have recorded facts. Daily records of temperature, humidity and volume of air in circulation are suggested to establish very closely for each particular locality the times of the year at which the pendulum of moisture swings to the side where the mines are robbed of moisture, and *vice versa*. This knowledge could be applied to those mines in which it is evident that dry conditions are apt to reach the danger point.

THE CRITICAL TEMPERATURE.—Assuming 60° outside temperature as our critical temperature when a dry condition exists in the mines, let us consider Table II. This table shows that the total number of explosions in the last 10 years was 52, and of these 47 occurred either at 60° or below. This represents 90% of all explosions from all causes. Considering fatalities, 1,812 out of 2,126, or 85.23% of the total, were caused either at or below this temperature.

TABLE III.—EXPLOSIONS AT VARIOUS RANGES OF TEMPERATURE.

Range of Temperature, Degrees Farenheit.	Explosions. No.	Explosions. Per cent.	Fatalities. No.	Fatalities. Per cent.	Number Fatalities Per Explosion.
10 to 20	9	17.31	740	34.80	82.22
20 to 30	14	26.92	429	20.18	30.64
30 to 40	13	25.00	489	23.00	37.62
40 to 50	5	9.62	63	2.97	12.60
50 to 60	6	11.54	91	4.28	15.16
60 to 70	5	9.61	314	14.77	60.30
Total..10 to 70	52	100.00	2,126	100.00	40.90

If we were able to eliminate all of those explosions which were due to gas, pure and simple, and not affected by dust, the figures would be far more conclusive. I have previously pointed out that I consider all of those explosions which occurred above the temperature of 60° F. as gas-explosions and not influenced by dust. The indication is that during the period under consideration we have not experienced a dust-explosion when the outside temperature was above 60° F. Close study of data (to be collected) may show that the temperature may fall from 5° to 10° below this point before danger of dust-explosions will be experienced.

Table III. shows that as the temperature falls below 40° the number of fatalities increases greatly. It is my opinion that the increased number of fatalities listed between the temperatures of 50° and 60° is caused by the fact that there are included certain gas-explosions which swell the total. Even so, the data indicate that 60° of outside temperature is dangerous. The cause of this increase in number of fatalities as the temperature falls, naturally follows from the fact that mines become drier as the temperature falls, and the extent and violence of a particular explosion vary in some way directly as the dry area in the mine. The presence of gas, of course, will increase the violence. But back of all is the question of humidity, which is so closely linked with temperature in its rise and fall.

SUGGESTED REMEDY.—There must be a practical solution to this problem, and I believe it can be found. The method of spraying by means of a car, or by means of pipe-lines with sprays located at intervals, I regard as unsatisfactory and wasteful of water in the first case, and very expensive and cumbersome in the latter. The use of calcium chloride, $CaCl_2$, as a deliquescent is excellent for haulage-ways and partings, but it will prove very expensive if used in all working-places, in which most of the dust is generated and where the greatest danger from explosion lies. White-washing, and the use of slate and shale-dust as a damper for explosive conditions, of course possess merit, but these are local preventive measures, and require too much time and supervision to be followed systematically. I am inclined to the view that it will be necessary to install a blower-system such as is used in ventilating large office-buildings, which heats the air to the required temperature. The air, having been heated to a temperature equal to the critical temperature, must be saturated with moisture at that point. This saturation would best be done near the intake, inside the mine. This method of control would be less expensive, and more economical in the consumption of water, than the intricate watering-sys-

FIG. 5. DUMPING THE SCOOPS OF THE DITCHING MACHINE.
(On the railway where the ditcher is used, the excavated material can usually be dumped at a point a few hundred yards from the cut.)

*"Bulletin," American Institute of Mining Engineers, June, 1909, p. 568.

tems which are laid in each entry of the whole mine, and being concentrated in a small area it could be regulated automatically.

The installation of such a system in dangerously dusty mines would reduce explosions from dust to a minimum. It may be found that certain portions of mines will still be persistently dusty, just as we find such spots, even in mid-summer. These troublesome places can be dampened by a spraying-car or by some other local means of application. Moreover, in all cases and with whatever auxiliaries, that system of mining the coal should be practiced which will produce the minimum quantity of dust, and the method of firing and the explosives used should be determined by considerations of safety.

Summary of Conclusions.

1. There is a certain condition of the outside air, having a temperature and humidity such that, when it is used in ventilating mines, moisture will neither be deposited in the mines nor carried out of them. This condition I call the "critical condition." And this condition probably varies slightly according to latitude, altitude, and the seasons of the year. This range of variation will probably fall between temperatures of 50° and 60°.

2. As the temperature of the outside air falls below the critical point, mines will be robbed of moisture by the ventilating-current (and vice versa).

3. While this lower outside temperature continues, the mine will become drier, and in proportion to the difference between this lower outside temperature and the critical point, the rate of drying will be increased or diminished.

4. When the outside temperature is such as to make the ventilating-current dry the mine, this effect will be increased by increasing the volume of the current.

5. This critical condition should be determined, and a ventilating-and-heating system should be adopted which would raise the temperature of the intake air to the mine-temperature, and then saturate the air with moisture.

The Reservoir Possibilities of the Sources of the Mississippi and Tributaries of the Upper Mississippi River with Reference to the Improvement of Navigation.

By CHARLES W. DURHAM.*

In this paper it will be the endeavor of the writer to show:

(1) The greatest practicable extent to which the reservoir systems may be carried with a view to obtaining the greatest possible discharge during periods of summer and fall low water in the Mississippi River, and the probable quantity of such discharge.

(2) The effect of the proposed reservoirs upon the improvement of navigation of the Mississippi River at and below St. Paul.

In the study access has been had to all of the printed reports of the various district engineer officers of the Army connected with reservoir exploration and operation from 1869 to 1909, and of their assistants, and also to many additional documents and maps, all of which are supplemented by the writer's own knowledge of the improvement of the Mississippi River gained by 38 years' experience in the work, and by other information found in the U. S. Engineer Office at Rock Island, Ill.

No attempt will be made to give the probable cost of building and operating these reservoirs, or to reconcile the various conflicting interests which may arise from their construction. It is the writer's belief, however, that these reservoir systems carried out to their fullest extent can be made to subserve both the interests of navigation and of water power, besides acting as a potent restraint of floods. Under such circumstances it might be to the advantage of water power interests to come in and relieve the Government of an equitable part of the cost. It is also believed that a very great part of the flowage damages, which have been and always will be one of the most expensive features of reservoir construction, could be avoided by drawing down the water in the lakes and ponds to a greater extent than hitherto proposed or practiced, thereby taking more advantage of their natural capacity than has heretofore been done, which result can in most cases be attained by locating the aprons of the dams at a much lower elevation and then dredging proper channels to the gates and sluices of the dams both above and below. The reservoir capacity could also be further increased by dredging in the basins, which could often be very cheaply done with a suction dredge, and possibly a berm or levee could be built at the same time around the lakes, and adjacent lands could be raised, with manifestly excellent results.

Prior to the surveys made by Major Allen in 1879, 1880 and 1881, which have given us the greater part of our information in regard to reservoir sites in Minnesota and Wisconsin, preliminary surveys and examinations had been made by Gen. Warren, in 1869, and Col. Farquhar in 1874. The main object of all these surveys was to ascertain the extent to which the impounded water could be applied to the improvement of the navigation of each stream, and ultimately to that of the main river. But the reservoir systems so far as built by the Government are intended primarily for the benefit of the navigation of the Mississippi River, and incidentally to mitigate its floods. The object of the reservoirs already constructed at the headquarters of the Mississippi River is to collect the surplus water, principally from the precipitation of winter, spring and early summer, to be systematically released so as to benefit navigation upon the Mississippi River below the reservoir dams. In 1905, the district officer said:

> The expenditure has resulted in benefit during the low water season to the navigable portions of the Mississippi River from Cass Lake to Lake Pepin and below, and incidentally to the mitigation of the floods in the river at St. Paul.

The examinations and surveys that have been made and the additional claims presented in this report, perhaps on somewhat insufficient grounds, do not represent the total possibilities; in fact it is manifest that far greater storage facilities could be shown to be available.

The district officer further said in 1907:

> The original project [for the reservoirs at the headwaters of the Mississippi River] calls for the construction of 41 reservoirs. . . . The efficiency of the reservoir system could also be greatly increased at small expense by dredging the channels above the dams and those connecting the various lakes that constitute the reservoirs. The aprons of the dams are now several feet below the level to which the water can be drawn down through the existing contracted channels.

The results as to precipitation, run-off, discharge and velocity of streams, etc., given in the

TABLE I.—DRAINAGE BASINS OF THE UPPER MISSISSIPPI RIVER VALLEY.

Designation.	Square miles.	Sq. ft.
Mississippi River above junction with the Minnesota	21,600	602,173,440,000
Minnesota River	12,119	337,858,329,600
Vermillion River	237	6,607,180,800
St. Croix River	7,568	210,983,731,200
Cannon River	1,690	47,114,496,000
Trimbelle (95), Isabelle (73) and Rush (183) rivers	351	9,785,318,400
Chippewa River	9,602	267,688,396,800
Zumbro River	1,604	44,716,953,600
Beef (452) and Whitewater (382) rivers and Eagle (158) and Rollingstone (136) creeks	1,128	31,446,835,200
Trempealeau River	700	19,514,880,000
Black (2880) and La Crosse (463) rivers	3,343	93,197,491,200
Root River	1,685	46,975,104,000
Bad Axe River (180) and two creeks (209)	389	10,844,697,600
Upper Iowa River	939	26,177,817,600
Yellow River (270) and several creeks (382)	652	18,176,716,800
Wisconsin River	11,850	330,359,040,000
Turkey River	1,589	44,298,777,600
Galena River (185), Grant River (289), Platte River (306) and several creeks (357)	1,137	31,697,740,800
Maquoketa River	1,863	51,937,459,200
Apple River (245), Rush Creek (85) and Plum River (280)	610	17,005,824,000
Wapsipinicon River	2,490	69,417,216,000
Rock River	10,690	298,020,096,000
Iowa River	12,250	341,510,400,000
Edwards River and creeks (638), Henderson River and creeks (1227)	1,865	51,993,216,000
Flint and two other creeks	334	9,311,385,600
Skunk River	4,322	120,490,444,800
Des Moines River	14,955	416,921,472,000
Fox River (479), Bear Creek (418) and Wyaconda Creek (480)	1,377	38,388,556,800
Fabius (1500), North and South rivers (1496)	3,086	86,032,742,400
Salt River	2,741	76,414,694,400
Cuivre River (1180) and seven creeks (482)	1,662	46,333,900,800
Illinois River	27,465	765,680,256,000
Piasa Creek and Wood River	245	6,830,208,000
Totals	164,138	4,575,904,819,200

(The figures in parenthesis represent the square miles of water shed of the small rivers and creeks.)

Fig. 1. Map of the Upper Mississippi River From St. Louis to Minneapolis.

*Principal Assistant U. S. Engineer; U. S. Engineer Office, Upper Mississippi River Improvement, Rock Island, Ill.

TABLE II.—RESERVOIR SITES AT HEADWATERS OF THE MISSISSIPPI AND MINNESOTA RIVERS.

Location.	Drainage area. (1 = 1,000,000)	Reservoir capacity. (1 = 1,000,000)	Mean annual run-off (1 = 1,000,000)	Discharge for 90 days.
	Sq. ft.	Cu. ft.	Cu. ft.	Sec. ft.
†Lake Winnibigoshish...	36,326	43,992	16,710	2,149
†Leech Lake.....	26,763	33,094	12,311	1,583
†Pokegama Falls.....	17,424	5,260	8,015	676
†Sandy Lake.....	11,402	3,158	5,245	406
†Pine River.....	15,082	7,733	6,938	892
Vermillion River.....	12,074	5,771	8,450	742
Mud Lake.....	4,461	2,885	3,122	371
Gull Lake.....	7,583	12,000	11,898	1,530
Mille Lacs.....	12,406	9,000	8,684	1,115
Crow Wing River.....	94,229	6,753	91,393	868
Long Prairie River.....	6,412	3,300	3,186	410
Total for Miss. River..	244,162	132,946	175,952	10,742
Big Stone Lake and Lake Traverse	81,293	33,000	33,000	4,243
Grand Total.....	325,455	165,946	208,952	14,985

*In all of the tables the term "Reservoir Capacity" means the amount of water that can be drawn off.
†Reservoirs already built.

following tables and pages of this paper, were obtained by constant study and effort during the past 30 years, and are believed to be accurate. The results, only, are given, without any attempt to explain the methods adopted. It will be noted that a number of the data are given in million cubic feet and square feet as the unit.

In Table I. are shown the areas of the drainage basins of the various tributaries of the Mississippi River above the mouth of the Missouri. (See Fig. 1 for the locations.) The figures in this table were mostly taken from Gen. Warren's report on bridging the upper Mississippi River, but they were revised by the writer many years ago and some important changes were made.

Reservoir Sites on the Upper Mississippi and Tributaries.

Table II. gives the drainage areas, the mean annual run-off (which is usually taken as one-fourth of the rain fall), the known storage capacity of the reservoirs already constructed and in operation (the first five on the list), and the estimated capacity of several sites, some of which have been surveyed and others suggested; all of these are tributary to the upper Mississippi above the Falls of St. Anthony, excepting Big Stone Lake and Lake Traverse, which are in the Minnesota basin. The practicable discharges in second-feet for 90 days are also given.

The combined estimated discharge of all these reservoirs, built and proposed, could doubtless be brought up to the 14,985 cu. ft. per sec. for 90 days as given in the table. It will be noted that the entire drainage area of these two streams is 940,031,769,600 sq. ft., while that of the selected reservoir sites amounts to but 325,435,000,000 sq. ft.—about 35%, and, further, that of the total calculated run-off of 208,952,000,000 cu. ft., only 165,946,000,000 cu. ft., or about 80%, is available for the purposes mentioned in this paper. From the well-known character of the country at the headwaters of these two streams, it is believed that a much greater area of storage ground could be made available than the table indicates.

ST. CROIX RIVER.—Table III. gives information similar to the former one, but none of the reservoirs have been built. The information was chiefly obtained from surveys made in 1879, 1880 and 1881, and it is believed that further examination would disclose additional favorable sites for reservoirs. In fact, it is noted that while the entire drainage area of the St. Croix is 210,983,731,200 sq. ft., that of the selected reservoir sites only amounts to 109,952,000,000 sq. ft., or about 52%, and that the run-off is more than double the capacity of the reservoirs.

TABLE III.—RESERVOIR SITES AT HEADWATERS OF ST. CROIX RIVER.

Location.	Drainage area. (1 = 1,000,000)	Reservoir capacity (1 = 1,000,000)	Mean annual run-off (1 = 1,000,000)	Discharge for 90 days.
	Sq. ft.	Cu. ft.	Cu. ft.	Sec. ft.
Mud Lake.....	767	396	537	51
Rice Lake.....	3,748	2,475	2,625	318
Yellow River.....	4,447	3,403	3,113	437
Veazies	12,155	1,379	8,508	177
Mouth of Totogatic (1)..	5,910	3,082	4,137	396
Upper Totogatic.....	1,984	1,389	1,389	178
Gilmore Lake.....	7,216	2,881	5,051	370
Mouth of Totogatic (2)..	1,645	1,541	1,131	145
Eau Claire Lakes.....	1,979	961	1,386	124
Upper St. Croix.....	6,105	4,698	4,274	604
Clam Lake	7,904	4,671	5,532	602
Lower St. Croix.....	28,715	2,710	20,100	349
Ground House.....	3,234	1,045	2,264	134
Chengwatana	24,143	3,703	16,900	476
Total for the St. Croix..	109,952	34,334	76,947	4,361

CANNON RIVER.—There follows in Table IV. similar information in regard to the Cannon River, which has a drainage area of 1,690 sq. miles and a mean annual discharge of 31,350,000,000 cu. ft., about 1,000 cu. ft. per sec. during the entire year. This stream enters the Mississippi four miles above Red Wing.

TABLE IV.—RESERVOIR SITES AT HEADWATERS OF THE CANNON RIVER.

Location.	Drainage area. (1 = 1,000,000)	Reservoir capacity. (1 = 1,000,000)	Mean annual run-off (1 = 1,000,000)	Discharge for 90 days.
	Sq. ft.	Cu. ft.	Cu. ft.	Sec. ft.
Above Northfield.....	7,902	5,000	5,000	643
Horse Shoe & Mud Lakes	3,946	2,500	2,500	322
Total for Cannon River.	11,848	7,500	7,500	965

sec. Reservoirs of about the capacity of those on the Cannon will add about 1,000 sec.-ft. for 90 days to the Mississippi River, into which it enters by two mouths—one two miles and the other six miles below the mouth of the Chippewa.

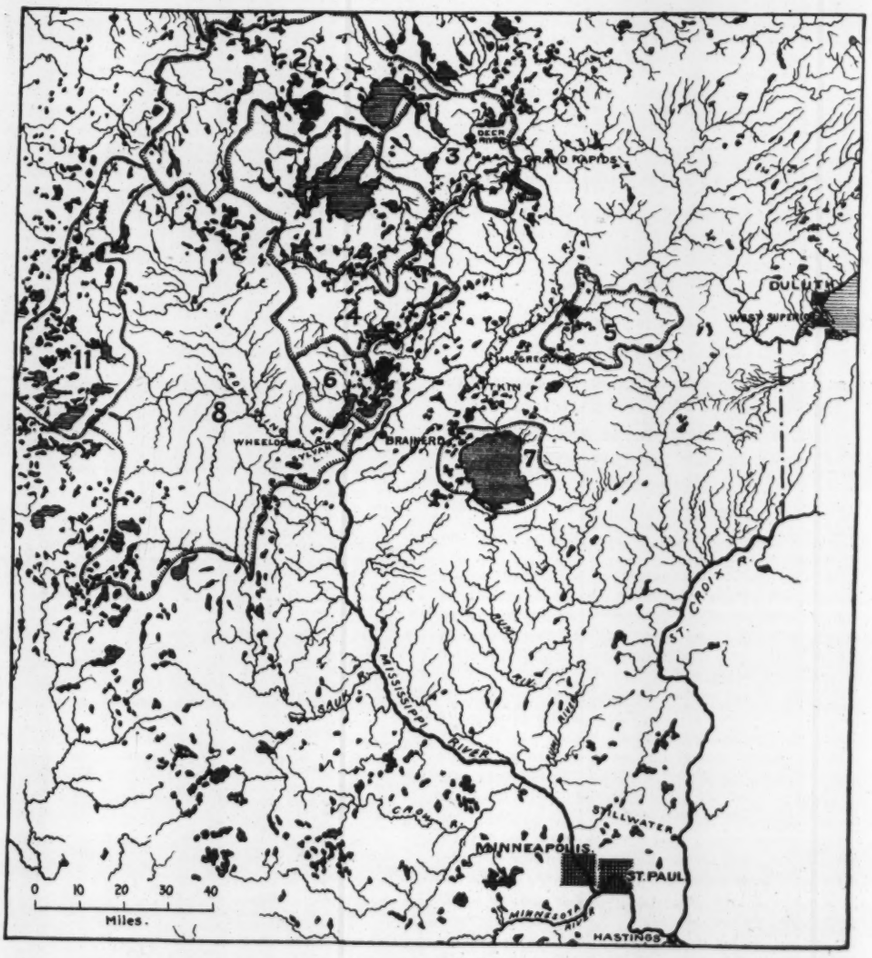


FIG. 2. MAP SHOWING LOCATION OF RESERVOIR SITES ON UPPER MISSISSIPPI RIVER IN MINNESOTA.

1. Leech Lake—Built.
2. Lake Winnebegoshish—Built.
3. Pokegama Falls—Built.
4. Pine River—Built.
5. Sandy Lake—Built.
6. Gull Lake.
7. Mille Lacs.
8. Crow Wing River.
11. Otter Tail Lake.

All of the figures in the case of the Cannon are estimated and are not the result of accurate surveys.

CHIPPEWA RIVER.—Table V. covers the reservoir sites of the Chippewa River, as obtained from the surveys of 1879–1881. In this river the total drainage area is 267,688,396,800 sq. ft., and that of the selected reservoir sites, 153,689,000,000 sq. ft., or about 58%. The run-off is about 5½ times the capacity of the reservoirs, indicating that their capacity could probably be trebled without difficulty.

ZUMBRO RIVER.—This stream has not been accurately surveyed, but the following information has been gleaned from county maps and from reconnoissances:

The drainage area is 1,604 sq. miles, or 44,716,953,600 sq. ft., which affords an annual run-off of 37,264,128,000 cu. ft., or 1,184 cu. ft. per

BLACK RIVER.—This stream, like the Zumbro, has not been accurately surveyed. The drainage area is 2,880 sq. miles, or 81,389,792,000 sq. ft., which affords an annual run-off of 67,824,826,666 cu. ft., or 2,150 cu. ft. per sec.

Reservoirs of a capacity sufficient to afford 1,500 sec.-ft. for 90 days can readily be built on suitable sites.

ROOT RIVER.—This stream, which enters the Mississippi about five miles below the Black, has not been accurately surveyed. Its drainage area is 1,685 sq. miles, or 46,975,104,000 sq. ft., which affords an annual run-off of 39,145,920,000 cu. ft., or 1,240 cu. ft. per sec. Reservoirs of a capacity sufficient to afford 1,000 cu. ft. per sec. for 90 days can be built on suitable sites.

UPPER IOWA RIVER.—This stream enters the Mississippi about nine miles below Genoa. Its drainage area is 939 sq. miles, or 26,177,817,600

TABLE V.—RESERVOIR SITES AT HEADWATERS OF THE CHIPPEWA RIVER.

Location.	Drainage area. (1 = 1,000,000) Sq. ft.	Reservoir capacity. (1 = 1,000,000) Cu. ft.	Mean annual run-off (1 = 1,000,000) Cu. ft.	Discharge for 90 days. Sec. ft.
Bear Lake	6,816	1,113	5,678	143
Little Chief Lake	1,606	771	1,358	99
Moose Lake	5,975	2,622	4,977	260
Pakwawang Lake	7,170	6,194	5,973	796
Courts Oreilles Lake	3,178	1,986	2,647	256
Paint Creek	109,927	505	91,570	65
Butternut Lake	1,115	585	929	75
Rest Lake	5,900	1,840	4,897	237
Bear Creek	4,307	5,407	3,107	695
Round Lake	1,757	1,303	1,382	168
Squaw Lake	1,087	732	864	94
Park Lake	4,851	621	4,026	80
Total for the Chippewa	153,689	23,079	127,388	2,968

sq. ft., which affords an annual run-off of about 21,815,000,000 cu. ft., or 692 cu. ft. per sec. A reservoir affording 500 cu. ft. per sec. for 90 days can be built.

WISCONSIN RIVER.—This was surveyed in 1879–1880 and 1881, and reservoir sites were carefully selected. (Table VI.) The entire drainage area of this stream is 11,850 sq. miles, or 330,359,040,000 sq. ft., and of the proposed reservoirs, 39,323,000,000, or about 12%, and the run-off 31,753,000,000 cu. ft., which is about 1⅘ times the capacity of the reservoirs. It is thought that the reservoir capacity and the 90-day discharge of 2,499 sec.-ft. could be much increased.

TURKEY RIVER.—No accurate surveys of this stream have been made. Information obtained from county and post office maps show a drainage area of 1,589 sq. miles, or 44,298,777,600 sq. ft., which indicates a run-off of 36,900,000,000 cu. ft., or about 1,170 sec.-ft. A reservoir affording a 90-day discharge of 1,000 sec.-ft. can be built on this river, which empties into the Mississippi opposite Cassville, Wis.

MAQUOKETA RIVER.—This stream enters the Mississippi about eight miles below Bellevue, Ia. It has a drainage area of 1,863 sq. miles, or 51,937,459,200 sq. ft., with a run-off of 43,281,216,000 cu. ft., or 1,372 sec.-ft. per annum. Reservoirs of a capacity of 1,000 sec.-ft. for 90 days can be built on this stream.

WAPSIPINICON RIVER.—This stream comes into the Mississippi four miles above Cordova. It has a drainage area of 2,490 sq. miles, or 69,417,216,000 sq. ft., which affords a run-off of 57,847,680,000 cu. ft., or 1,834 sec.-ft. per annum. Reservoirs of a discharge capacity of 1,500 sec.-ft. for 90 days can be built on this river.

ROCK RIVER.—A survey of the Rock River was made in 1881 and reservoir sites selected as shown in Table VII. This stream, which enters the Mississippi just below the city of Rock Island, has a drainage area of 10,690 sq. miles, or 298,020,096,000 sq. ft., while the drainage area of the proposed reservoirs embrace 102,488,000,000 sq. ft., or about 35%. The capacity of the reservoirs, which will discharge 6,221 sec.-ft. for 90 days, is about four-fifths of the run-off.

IOWA RIVER.—This is one of the large tributaries, although not considered a navigable stream. It enters the Mississippi nearly opposite New Boston, and has a drainage area of 12,250 sq. miles, or 341,510,000,000 sq. ft., affording an annual run-off of 284,591,666,667 cu. ft., or about 9,024 cu. ft. per sec. While no accurate surveys of this stream are available,

TABLE VI.—RESERVOIRS AT HEADWATERS OF THE WISCONSIN RIVER.

Location.	Drainage area. (1 = 1,000,000) Sq. ft.	Reservoir capacity. (1 = 1,000,000) Cu. ft.	Mean annual run-off (1 = 1,000,000) Cu. ft.	Discharge for 90 days. Sec. ft.
Pelican	8,391	5,153	6,837	663
Sugar Camp	1,673	1,356	1,336	174
Otter Rapids	12,462	7,390	10,028	950
Tomahawk	2,830	2,226	2,202	283
Squirrel Lake	1,561	1,338	1,239	159
Rice Lakes	11,040	1,044	9,130	134
Vieux Desert	530	400	360	52
Twin Lakes	836	650	621	84
Total for the Wisconsin	39,323	19,557	31,753	2,499

enough is known of its headwaters to warrant the statement that reservoirs can be built and operated without difficulty, capable of contributing 7,000 sec.-ft. for 90 days.

SKUNK RIVER.—The Skunk River enters the Mississippi about eight miles below Burlington, and has a drainage area of 4,332 sq. miles, or 120,490,444,800 sq. ft., indicating an annual run-off of 100,408,704,000 cu. ft., or 3,184 cu. ft. per sec. This stream will afford, it is believed, sites for reservoirs capable of discharging 2,500 sec.-ft. for 90 days.

DES MOINES RIVER.—Next to the Illinois, this is the largest tributary of the upper Mississippi, which enters the main stream about three miles below Keokuk; it has a drainage

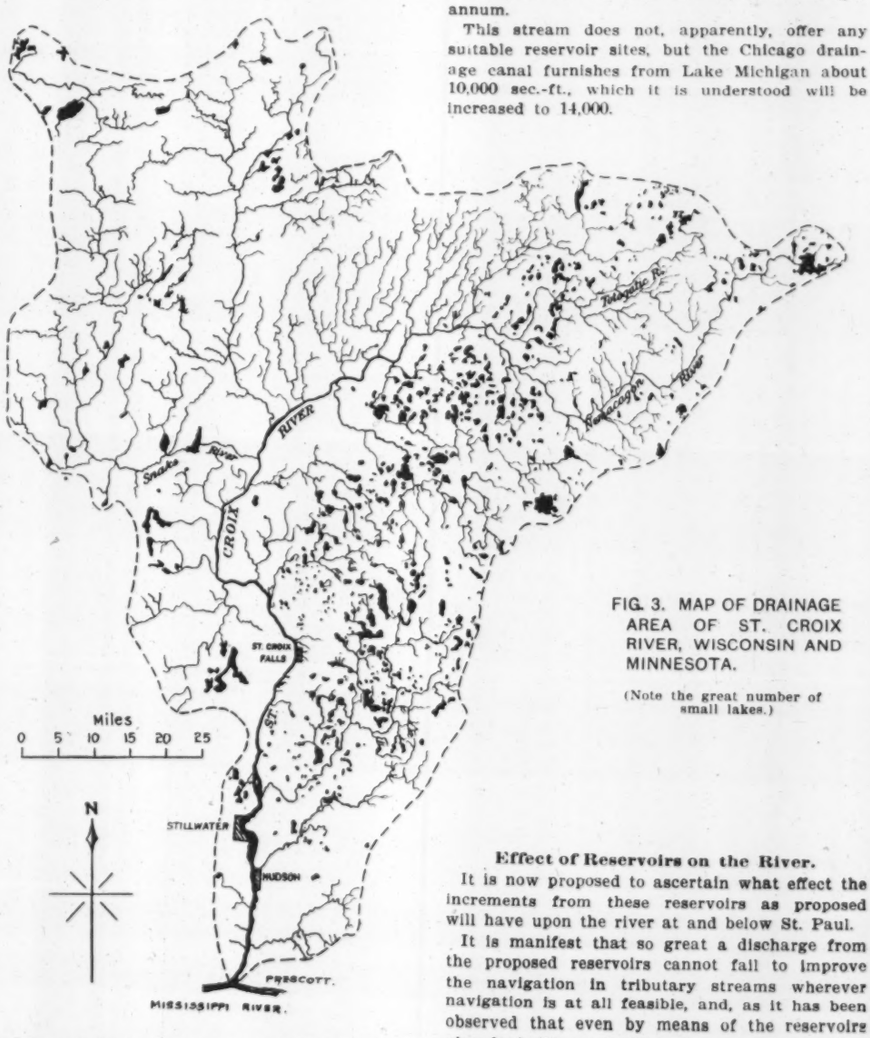


FIG. 3. MAP OF DRAINAGE AREA OF ST. CROIX RIVER, WISCONSIN AND MINNESOTA.

(Note the great number of small lakes.)

area of 14,955 sq. miles, or 416,921,472,000 sq. ft., affording an annual run-off of 347,434,560,000 cu. ft., or 11,017 sec.-ft. Nothing very definite is known of the reservoir conditions on this stream, but it is believed a 90-day discharge of 7,500 sec.-ft. can be secured.

FABIUS NORTH AND SOUTH RIVERS.—These streams coming into the Mississippi, near together, a few miles below Quincy, have a combined drainage area of 3,086 sq. miles, or 86,032,742,400 sq. ft., which indicates an annual run-off of 71,693,952,000 cu. ft., or 2,273 sec.-ft. Small reservoirs on each of these streams will furnish combined about 1,500 sec.-ft. for 90 days.

SALT RIVER.—This tributary enters the Mississippi just above Louisiana, Mo. It has a drainage area of 2,741 sq. miles, or 76,414,694,000 sq. ft., indicating an annual run-off of 63,678,912,000 cu. ft., or about 2,019 sec.-ft. for 90 days.

ILLINOIS RIVER.—This is the largest tributary of the upper Mississippi River; it has a

TABLE VII.—RESERVOIRS AT HEADWATERS OF THE ROCK RIVER.

Location.	Drainage area. (1 = 1,000,000) Sq. ft.	Reservoir capacity. (1 = 1,000,000) Cu. ft.	Mean annual run-off (1 = 1,000,000) Cu. ft.	Discharge for 90 days. Sec. ft.
Lake Horicon	13,688	8,000	8,000	1,027
Beaver Dam Lake	262	.....	.....	50
Lake Koshkonong	70,811	30,000	40,000	3,858
Lake Mendota	16,727	10,000	10,000	1,286
Total for Rock River	102,488	48,000	58,000	6,221

drainage area of 27,645 sq. miles, or 765,680,256,000 sq. ft., which affords a run-off of 638,066,880,000 cu. ft., or about 20,233 sec.-ft. per annum.

This stream does not, apparently, offer any suitable reservoir sites, but the Chicago drainage canal furnishes from Lake Michigan about 10,000 sec.-ft., which it is understood will be increased to 14,000.

Effect of Reservoirs on the River.

It is now proposed to ascertain what effect the increments from these reservoirs as proposed will have upon the river at and below St. Paul.

It is manifest that so great a discharge from the proposed reservoirs cannot fail to improve the navigation in tributary streams wherever navigation is at all feasible, and, as it has been observed that even by means of the reservoirs already built, good effects have been secured in

TABLE VIII.—SUMMARY OF RESERVOIR INCREMENTS, UPPER MISSISSIPPI RIVER.

Miles from St. Paul.	Names of Tributaries.	Drainage area, total. Sq. mi.	90-day discharge. For each stream. Sec. ft.	90-day discharge. Combined. Sec. ft.
0	Upper Mississippi and Minnesota	33,719	14,985	14,985
30	St. Croix	7,568	4,361	19,346
45	Cannon	1,090	965	.....
77	Chippewa	9,602	2,968	23,279
84	Zumbro	1,604	1,000	.....
144	Black	2,880	1,500	.....
149	Root	1,685	1,000	.....
172	Upper Iowa	935	500	.....
212	Wisconsin	11,850	2,499	29,778
235	Turkey	1,589	1,000	.....
296	Maquoketa	1,863	1,000	.....
338	Wapsipinicon	2,490	1,500	.....
366	Rock	10,690	6,221	.....
410	Iowa	12,250	7,000	46,499
450	Skunk	4,322	2,500	.....
487	Des Moines	14,955	7,500	.....
525	Fabius, North & South	3,086	1,500	57,999
566	Salt	2,741	1,500	.....
635	Illinois	27,465	10,000	69,499
	Total	.....	69,499	.....

checking and abating floods, it is also certain that an enlargement of the system as indicated would be still further beneficial.

The unhampered portions of the drainage areas not only at the headwaters but also along the Mississippi, both above and below St. Paul, cannot fail, when aided by the surplus water the reservoirs will be unable to store, to keep the river at a good stage during the spring and early summer months, so that no reservoir accretion will usually be needed until August. Then for a period of about 90 days, generally, although not always, the need of the reservoirs will be felt.

In previous operation of the reservoirs, too little credit has been given to the contraction of the low-water channel made by the U. S. Engineers in the improvement of the river below St. Paul, for without the aid of this contraction the good effects of reservoirs already built would be hardly noticeable at St. Paul, and not at all below Lake Pepin.

In an unimproved state the addition of a foot, or even two or three feet, does not necessarily deepen the water on the bars; in fact such an accretion often has the effect of a rising river, which obliterates the scour resulting from a falling one. The writer can cite many instances in past years when the depth in the channel at certain localities was less than the stage, and when after a fall of several feet the depth was much greater than before.

The stage at St. Paul, which under present conditions the district engineer proposes to maintain at 3 ft. above low water, is no criterion of the stage at other points. The stage may be 10 ft. at St. Paul and only 2 ft. at Keokuk or Louisiana, and vice versa. While this is being written the stage at St. Paul is 5 ft. and at Rock Island 11 ft.

The attempt to maintain the stage at St. Paul at 3 ft. is a good thing so far as the improvement of the river from St. Paul to Lake Pepin is concerned, but it is a confession of weakness as regards the river below the lake.

But the river between St. Paul and Lake Pepin no longer needs this increment to make it better as regards navigability than the river below the lake, for the Government has already improved this portion of the river so that there will always be a 4½-ft. depth at low water from St. Paul to Prescott, with a channel 350 ft. wide, and 5 ft. from Prescott to Lake Pepin, with a channel 600 ft. wide, without any reservoir aid, provided the existing improvements are maintained.

What is now wanted, the writer believes, is a discharge of some or all of the reservoirs to their full 90-day capacity, to commence when at any point on the Mississippi River above the Illinois River the stage reaches 3, or perhaps even 4 ft., with a falling tendency. Accurate watch must be kept over all the gages along the river, and the various reservoirs must be skillfully manipulated in order to contribute water when and where most needed, due regard being had to the length of time required for the water from more or less distant reservoirs to come into action. On the skillful and watchful treatment of the reservoir increments will depend the measure of success.

A project for a 6-ft. channel from St. Paul to the mouth of the Missouri River, to take the place of the 4½-ft. project upon which operations have been carried on since 1878 with good results, was submitted by Major C. S. Riché, Corps of Engineers, U. S. A., in October, 1906, and was adopted by Congress early in 1907. This project, which was compiled by the writer, calls for the protection of caving banks and for channel contraction by means of wing, closing, and trailing dams, the proposed contraction being greater than in previous projects and reducing the formerly proposed channel widths. Provision is also made for auxiliary dredging to remove from the channel accumulations of sand liable to drift and lessen the depth at critical points, and for rock excavation at various localities, as also for the further improvement of Rock Island Rapids and Des Moines Rapids. The estimate of cost is $20,000,000, the work to be completed in from 10 to 20 years.

The success that has attended the efforts to secure a 4½-ft. channel warrants the belief that 6 ft. can be obtained by further contraction.

The channel widths to be obtained by contraction have been determined by comparison and discharge at low water, aided by experience, and are as follows:

	Ft.
St. Paul to mouth of St. Croix River	300
St. Croix River to Lake Pepin	600
Lake Pepin to Alma	525
Alma to Genoa	625
Genoa to Wisconsin River	700
Wisconsin River to Rock Island Rapids	900
Rock Island Rapids, by canal and rock excavation	200-250
Rock Island to Des Moines Rapids	1,000
Des Moines Rapids	200
Keokuk to Hannibal	1,000
Hannibal to Illinois River	1,200
Illinois River to Missouri River	1,400

The dams are to have a crest elevation of 4 ft. above low water from St. Paul to the Des Moines Rapids, and 6 ft. from Keokuk to the Missouri River.

Below is given, in Table IX., the stage, velocity, area of cross-section and discharge of the Mississippi River at St. Paul, obtained from a very large number of gagings made during a period of several years at Robert St. bridge. The results have been changed to conform to the U. S. Engineer gage at St. Paul, the zero of which is supposed to be at the elevation of low water of 1864. It is 0.5 ft. higher than the Weather Bureau gage, which was used in the gagings. When the river reaches a 4-ft. stage it pours over the dam on the west side of the river at Robert St., and the results as shown above that stage are not so accurate.

The gagings at St. Paul were made in recent years, since the river has been sufficiently regulated to permit 4½-ft. navigation at low water. Other tables follow, with similar information at Prescott, Winona, Clayton, Burlington, Hannibal and Grafton, but in these cases the gagings were made many years ago, before the channel regulation had made much progress. The second part of these tables shows the area and discharge under improved conditions, and also the effect of the reservoir increments.

We will now consider the effect of the reservoir increment 14,985 cu. ft. per sec., on the river at St. Paul. The normal low water flow as given in Table IX. is 2,375 cu. ft. per sec., but as about 35% of the natural water shed is preempted by the reservoirs, it is only fair to reduce the probably low water flow to that extent, leaving about 1,500 cu. ft. to be added to the water from the reservoirs, making a total quantity of 16,485 cu. ft. per sec. flowing under low water conditions at St. Paul. A glance at the table will show that this quantity of water will insure a 6-ft. stage without taking into consideration future contraction. Such an increment, in view of the 4½-ft. channel already secured, will do away with any further expenditure to secure a 6-ft. channel, except for a nominal amount of dredging. A saving of nearly $900,000 will result.

It is also interesting to note what smaller quantities of added water will do in the event of the full contraction of channel to 300 ft. in width and dams of 4-ft. elevation. Under the supposition that the contracted channel will have a rectangular cross-section of 6 ft. deep at low water (although the section will probably have an oval or irregular shape on the bottom), the results will be as shown in Table IX. It is probable that the velocities would be somewhat increased, but the factor of safety is very large, and it is readily seen that 4 ft. on the gage can be easily secured without making use of the full increment, and 4 ft. on the gage would mean 10 ft. in the channel. When the river exceeds a 4-ft. stage the water will pour over the dams, and from that stage up the width of section is figured at 1,000 ft., which is about the maximum width between St. Paul and the St. Croix.

AT MOUTH OF THE ST. CROIX RIVER.—We will now take up the river between the St. Croix and the Chippewa (Table X.). The area of the drainage area embraced by the reservoirs on and above the St. Croix is 38% of the total area, and therefore we are entitled to add 62% of the low water flow at the mouth of the St. Croix, or 3,565 sec.-ft., to the reservoir increment. The mean width of this section of river is about 1,000 ft., which takes effect when the stage is over 4 ft. and water running over the dams.

In its present partially improved state, the reservoir increment would produce a stage of about 5.5 ft., or 10 ft. in the channel, and make a saving of about $250,000 on the 6-ft. project. With full contraction to 600-ft. width of channel, a depth of about 13½ ft. can be attained.

AT MOUTH OF CHIPPEWA RIVER.—As regards the river between the mouths of the Chippewa and the Wisconsin, the area of water shed embraced by the reservoirs on and above the Chippewa is 41% of the total area, so that 59%, or 5,180 sec.-ft., should be added to the reservoir increment (Table XI.). The mean

TABLE IX.—THE MISSISSIPPI RIVER AT ST. PAUL.
(Reservoir increment, 14,985 sec. ft., plus natural low water flow, 1,500 sec. ft., equals 16,485 sec. ft.)

Stage above low water.	Mean velocity.	Partial improvement. Area of cross-section.	Partial improvement. Discharge.	After full improvement; channel 300 ft. wide. Area of cross-section.	After full improvement; channel 300 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	0.88	2,695	2,375	.....	.....
0.5	1.09	2,861	3,100	1,950	2,125
1.0	1.26	3,027	3,800	2,100	2,646
1.5	1.44	3,194	4,600	2,250	3,140
2.0	1.60	3,363	5,400	2,400	3,840
2.5	1.76	3,532	6,200	2,550	4,498
3.0	1.92	3,703	7,100	2,700	5,184
3.5	2.09	3,875	8,100	2,850	5,957
4.0	2.25	4,047	9,100	3,000	6,750
4.5	2.52	4,220	10,650	3,500	8,820
5.0	2.67	4,611	12,300	4,000	10,680
5.5	2.83	5,003	14,150	4,500	12,735
6.0	2.97	5,395	16,000	5,000	14,850
6.5	3.11	5,789	17,950	5,500	17,105
7.0	3.22	6,183	19,900	.....	.....
7.5	3.33	6,579	21,900	.....	.....
8.0	3.44	6,975	24,000	.....	.....

Note.—The above results (after full 6-ft. improvement) govern from St. Paul to the mouth of the St. Croix and indicate a 12-ft. channel depth.

TABLE X.—THE MISSISSIPPI RIVER AT MOUTH OF ST. CROIX RIVER.
(Reservoir increment, 19,346 sec. ft., plus natural low water flow, 3,565 sec. ft., equals 22,911 sec. ft.)

Stage above low water.	Mean velocity.	Partial improvement. Area of cross-section.	Partial improvement. Discharge.	After full improvement; channel 600 ft. wide. Area of cross-section.	After full improvement; channel 600 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	1.15	5,000	5,750	.....	.....
0.5	1.22	5,580	6,780	3,900	4,758
1.0	1.29	6,130	7,910	4,200	5,712
1.5	1.36	6,700	9,112	4,500	6,120
2.0	1.43	7,275	10,400	4,800	6,864
2.5	1.50	7,840	11,760	5,100	7,650
3.0	1.57	8,400	13,146	5,400	8,424
3.5	1.63	9,000	14,670	5,700	9,291
4.0	1.70	9,600	16,320	6,000	10,200
4.5	1.77	10,100	17,880	6,500	11,505
5.0	1.84	10,650	19,540	7,000	12,880
5.5	1.92	11,900	22,200	7,500	14,400
6.0	1.98	13,550	24,000	8,000	15,840
6.5	2.05	15,000	26,000	8,500	17,425
7.0	2.12	16,700	28,400	(Note.—Discharge above 5.5-ft. stage not reliable.)	
7.5	2.18	18,500	31,000		
8.0	2.26	20,800	33,300		

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the St. Croix to the mouth of the Chippewa and indicate a 13½-ft. channel depth.

TABLE XI.—THE MISSISSIPPI RIVER AT THE MOUTH OF CHIPPEWA RIVER. (Winona gaging.)
(Reservoir increment, 23,279 sec. ft., plus natural low water flow, 5,180 sec. ft., equals 28,459 sec. ft.)

Stage above low water.	Mean velocity.	Before improvement. Area of cross-section.	Before improvement. Discharge.	After full improvement; channel 525 to 700 ft. wide. Area of cross-section.	After full improvement; channel 525 to 700 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	1.62	5,400	8,780	.....	.....
0.5	1.72	6,300	10,880	4,550	7,826
1.0	1.82	7,150	13,010	4,900	8,918
1.5	1.91	8,000	15,280	5,250	10,027
2.0	2.00	8,875	17,770	5,600	11,200
2.5	2.09	9,775	20,430	5,950	12,436
3.0	2.18	10,650	23,300	6,300	13,730
3.5	2.27	11,550	26,300	6,650	13,096
4.0	2.36	12,400	29,330	7,000	16,520
4.5	2.45	13,300	32,590	7,750	18,988
5.0	2.54	14,200	36,000	8,500	21,590
5.5	2.62	15,100	39,560	9,250	24,235
6.0	2.70	16,000	43,280	10,000	27,100
6.5	2.78	16,800	46,790	10,750	29,993
7.0	2.87	17,700	50,770	.....	.....
7.5	2.95	18,600	54,960	.....	.....
8.0	3.04	19,400	59,070	.....	.....

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the Chippewa to the mouth of the Wisconsin and indicate a 12-ft. channel depth.

TABLE XII.—AT MOUTH OF WISCONSIN RIVER. (Clayton gaging.)

(Reservoir increment, 29,778 sec. ft., plus natural low water flow, 6,528 sec. ft., equals 36,306 sec. ft.)

Stage above low water.	Mean velocity.	Before improvement. Area of cross-section.	Before improvement. Discharge.	After full improvement; channel 900 to 1,000 ft. wide. Area of cross-section.	After full improvement; channel 900 to 1,000 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	0.65	14,800	9,600	.....	.....
0.5	0.77	15,700	12,090	6,500	5,005
1.0	0.89	16,350	14,550	7,000	6,230
1.5	1.00	17,000	17,000	7,500	7,500
2.0	1.12	17,700	19,910	8,000	8,960
2.5	1.24	18,400	22,820	8,500	10,540
3.0	1.35	19,100	25,785	9,000	12,150
3.5	1.46	19,800	29,010	9,500	13,870
4.0	1.58	20,500	32,490	10,000	15,800
4.5	1.70	21,200	36,040	11,000	18,700
5.0	1.83	22,000	40,260	12,000	22,200
5.5	1.95	22,700	44,270	13,000	25,350
6.0	2.06	23,400	48,320	14,000	28,840
6.5	2.18	24,100	52,660	15,000	32,700
7.0	2.31	24,800	57,290	16,000	36,960
7.5	2.42	25,600	61,950	17,000	41,140
8.0	2.55	26,450	67,450	18,000	45,900

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the Wisconsin to the mouth of the Iowa and indicate a 12½-ft. channel depth.

TABLE XIV.—THE MISSISSIPPI RIVER AT MOUTH OF FABIUS RIVER. (Hannibal gage.)

(Reservoir increment, 57,999 sec. ft., plus natural low water flow, 20,202 sec. ft., equals 78,201 sec. ft.)

Stage above low water.	Mean velocity.	Before improvement. Area of cross-section.	Before improvement. Discharge.	After full improvement; channel 1,200 ft. wide. Area of cross-section.	After full improvement; channel 1,200 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	1.50	18,200	27,300	.....	.....
0.5	1.64	18,900	31,000	7,800	12,792
1.0	1.78	19,600	34,990	8,400	14,952
1.5	1.93	20,300	39,280	9,000	17,370
2.0	2.09	21,000	43,890	9,600	20,064
2.5	2.24	21,700	48,610	10,200	22,848
3.0	2.38	22,400	53,420	10,800	25,704
3.5	2.53	23,100	58,440	11,400	28,842
4.0	2.67	24,000	64,100	12,000	32,040
4.5	2.82	24,900	70,220	13,350	37,647
5.0	2.96	25,750	76,350	14,700	43,512
5.5	3.12	26,625	83,070	16,050	50,076
6.0	3.26	27,500	89,650	17,400	56,724
6.5	3.41	28,500	97,185	18,750	63,938
7.0	3.55	29,400	104,370	20,100	71,355
7.5	3.80	30,400	115,520	21,450	81,510
8.0	3.86	31,400	121,204	.....	.....

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the Fabius to the mouth of the Illinois, and indicate a 13-ft. channel depth.

width of this section of the river (leaving out Lake Pepin) is 1,500 ft., when the water is running over the dams. In its present comparatively unimproved state, the reservoir increment will insure a 3.5-ft. stage, without, however, any certainty of much improvement in channel depth; but with the full contraction to 700 ft., a 6-ft. stage with 12 ft. in channel seems assured.

AT MOUTH OF WISCONSIN RIVER.—Between the mouths of the Wisconsin and the Iowa rivers are 200 miles of river, the mean width of which is about 2,000 ft. The reservoir drainage area is only 32% of the total drainage area on and above the Wisconsin, so that 68% of the low water flow is to be added to the reservoir increment, or 6,528 sec.-ft. A glance at Table XII. shows that the result will be a stage of 4.5 in the unimproved river, without, however, a guarantee of much increase in channel depth. But with the full 900 to 1,000 ft. contraction there will be a stage of 6.5 ft. and a depth of 12.5. At the Rock Island rapids, which are in this stretch of river, some modifications in the proposed improvement by lateral canal would probably have to be made, to secure the above mentioned result.

AT MOUTH OF IOWA RIVER.—Between the mouths of the Iowa and the Fabius, the mean width of the river is about 2,500 ft., and the difference in drainage areas, as described in previous cases, insures the addition of 72%, or 16,963 sec.-ft. Table XIII. shows a 4-ft. stage in the unimproved river and a 7-ft. stage under full contraction, the latter case representing a depth of about 13 ft. At the Des Moines rapids, which are included in this section of river, some modifications in the existing project would probably have to be made to secure above result.

AT MOUTH OF FABIUS RIVER.—From the Fabius to the Illinois, the mean width is about 2,700 ft. and the low water addition to the reservoir increment, 74%, or 20,202 sec.-ft. In this case Table XIV. gives a stage of 5 ft. for the unimproved river, and 7 ft.—or 13 ft. in the channel—for the full contraction.

AT MOUTH OF ILLINOIS RIVER.—From the Illinois to the Missouri the mean width is about 3,000 ft., and the low water percentage to be added, 77%, or 29,106 sec.-ft., making a gross flow of 98,605 sec.-ft., including 10,000 sec.-ft. from Lake Michigan through the drainage canal. This flow guarantees a stage of 5.5 ft. before improvement, and of probably 9.5 ft., or 15.5 ft. in the channel, with full improvement. (Table XV.)

The reservoir dams, five in number, at the headwaters of the Mississippi, were built of wood in the early eighties, and have been wholly or partly rebuilt with steel and concrete. The total cost to June 30, 1909, for construction, operation, and the payment of flowage and other damages, has been $1,792,297, of which for operating and care since 1895, $279,137. It would not be practicable, with the information at hand, to present a reliable estimate of the cost of the proposed system of reservoirs, but it is believed that such a system would insure a saving of $5,000,000 in carrying out the 6-ft. channel project, besides affording a much greater channel depth, and that the cost of maintenance and operation of both improvements would not exceed $1,000,000 a year. The benefits to navigation, not only on the main river, but on the tributaries, would be enormous; floods would be restrained and waterpowers created and benefited to an extent perhaps commensurate with the cost of the entire work.

The ideal plan for all interests would be reservoir systems controlling the whole or nearly all of the run-off and ensuring permanently equable flow, which is alike beneficial to navigation and to water power and an eradicator of floods.

TABLE XIII.—THE MISSISSIPPI RIVER AT MOUTH OF IOWA RIVER. (Burlington gaging.)

(Reservoir increment, 46,499 sec. ft., plus natural low water flow, 16,963 sec. ft., equals 63,462 sec. ft.)

Stage above low water.	Mean velocity.	Before improvement. Area of cross-section.	Before improvement. Discharge.	After full improvement; channel 1,000 ft. wide. Area of cross-section.	After full improvement; channel 1,000 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	1.45	16,250	23,560	.....	.....
0.5	1.57	17,225	27,040	6,500	10,205
1.0	1.71	18,202	31,120	7,000	11,970
1.5	1.85	19,179	35,480	7,500	13,885
2.0	1.99	20,158	40,110	8,000	15,920
2.5	2.13	21,137	45,020	8,500	18,105
3.0	2.27	22,118	50,210	9,000	20,430
3.5	2.41	23,100	55,670	9,500	22,895
4.0	2.55	24,082	61,410	10,000	25,500
4.5	2.69	25,065	67,430	11,250	30,463
5.0	2.83	26,050	73,720	12,500	35,375
5.5	2.97	27,035	80,300	13,750	40,828
6.0	3.10	28,021	86,870	15,000	46,500
6.5	3.23	29,007	93,690	16,250	52,488
7.0	3.37	29,995	101,080	17,500	58,975
7.5	3.50	30,983	108,440	19,000	66,500
8.0	3.64	31,973	116,380	.....	.....

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the Iowa to the mouth of the Fabius and indicate a 13-ft. channel depth.

TABLE XV.—THE MISSISSIPPI RIVER AT MOUTH OF ILLINOIS RIVER. (Grafton gage.)

(Reservoir increment, 69,499 sec. ft., plus natural low water flow, 29,106 sec. ft., equals 98,605 sec. ft.)

Stage above low water.	Mean velocity.	Before improvement. Area of cross-section.	Before improvement. Discharge.	After full improvement; channel 1,400 ft. wide. Area of cross-section.	After full improvement; channel 1,400 ft. wide. Discharge.
Ft.	Ft. per sec.	Sq. ft.	Sec. ft.	Sq. ft.	Sec. ft.
0.0	1.35	28,000	37,800	.....	.....
0.5	1.44	29,100	41,904	9,100	13,104
1.0	1.54	30,200	46,510	9,800	15,092
1.5	1.63	31,300	51,020	10,500	17,115
2.0	1.73	32,400	56,050	11,200	19,376
2.5	1.81	33,575	60,770	11,900	21,539
3.0	1.91	34,750	66,370	12,600	24,066
3.5	2.01	35,925	72,210	13,300	26,733
4.0	2.11	37,100	78,280	14,000	29,540
4.5	2.20	38,300	84,260	15,500	34,100
5.0	2.29	39,500	90,460	17,000	38,930
5.5	2.39	40,800	97,510	18,500	44,215
6.0	2.50	42,100	105,250	20,000	50,000
6.5	2.59	43,200	111,890	21,500	55,685
7.0	2.69	44,300	119,170	23,000	61,870
7.5	2.79	45,500	126,950	24,500	68,355
8.0	2.89	46,700	134,970	26,000	75,140

Note.—The above results (after full 6-ft. improvement) govern from the mouth of the Illinois to the mouth of the Missouri, and indicate a 15½-ft. channel depth.

In conclusion I would say that the reservoir scheme outlined in this paper appears to be capable of securing, in connection with the 6-ft. channel project, a navigable depth of at least 12 ft. at what would otherwise be extreme low water from St. Paul to the mouth of the Missouri—or, to give it in more detail:

	Ft.
From St. Paul to the St. Croix	12
From the St. Croix to the Chippewa	13.5
From the Chippewa to the Wisconsin	12.0
From the Wisconsin to the Iowa	12.5
From the Iowa to the Fabius	13.0
From the Fabius to the Illinois	13.0
From the Illinois to the Missouri	15.5

It is understood that the scheme outlined by the writer, although practicable, is extremely optimistic and that it is more than probable that the enormous cost of overflowed lands especially below St. Paul would militate against, and perhaps prevent its ever being carried out, at least to its full extent, although water power interests would probably contribute very liberally to its execution.

Rapid Deterioration of Steel Work from the Corrosive Action of Locomotive Gas. McCallie Avenue Bridge, Chattanooga, Tennessee.

A two-span steel truss bridge carrying McCallie Ave. across a nine-track railway switch-yard approach in Chattanooga, Tenn., has, within the past month, been closed to public use on account of the very marked reduction in the section of its lower members and floor system as a result of the corrosive action of locomotive gases. The bridge was completed in April, 1905, so that its life-time has been reduced at least 75% by the lack of protection against the gases. City Engineer Robert Hooke has presented to the City Council a report on the condition of the structure and from that report we have taken the most pertinent parts. It should be stated that the City Engineer's department is not at all responsible for the construction of the bridge, which was built jointly by the County of Hamilton and the railways before the territory on which it stands was acquired by the city.

The abstract of the report follows:

The Present Bridge.

The bridge which has been pronounced unsafe consists of two 120-ft. truss spans with inclined top chords, each span consisting of ten 12-ft. panels. The width of the bridge between centers of trusses is 41 ft. 8 ins. with sidewalks on each side 9 ft. in width from center of truss to inner face of sidewalk rail. Each panel of the floor is carried by steel plate girder floor beams spaced 12 ft. between centers. The double car tracks are carried between floor beams by 10-in. 25-lb., rolled I-beams, one under each rail. The flooring planks of the roadway outside the car tracks are supported by 7-in. 15-lb. rolled I-beams, spaced 2 ft. 9 ins. between centers. The sidewalk flooring is carried by 7-in. channels and 7-in. I-beams. The roadway flooring planks are of oak, 2½ ins. in thickness, and the sidewalk flooring is of pine, 1¾ ins. in thickness. Total length of the bridge spans is 242 ft., the length of the west approach 128 ft. and the east approach 369, making the total length of the bridge and viaduct approaches 739 ft., 497 ft. being covered by the approaches. The approaches are carried by steel trestles spaced 27 ft. centers, except at towers, where they are 20 ft. [The minimum clearance from bottom of floor system to top of rail is 20 ft.—Ed.]

Present Condition of Bridge Members.

A 7-in. channel stringer under the south sidewalk was found with its web practically destroyed through the effect of the locomotive exhaust discharges. The observed effect on this channel has been used as a criterion in estimating the amount of deterioration which the other and heavier steel members have undergone from the same cause. The channel mentioned had originally a web 0.21-in. in thickness. This thickness, having been reduced practically to a zero value, the perforations involving the entire web, it is clear that the metallic structure of the bar has been broken down for a depth of 0.105 in. measured inward from each side of the web. We may, therefore, assume that the destructive effects of the locomotive blasts have penetrated as deeply into the structure of the other and heavier steel members which have been similarly exposed. It may be stated that the correctness of this assumption has been verified by an in-

spection of the actual condition of several of the 7-in. I-beam stringers. The estimated loss of section of the floor and track stringers, floor beams and bottom chords follows:

(A) 7-in. rolled channel bar stringer under sidewalk. Original weight, 9.75 lbs. per ft. Original thickness of web, 0.21 in. Present available thickness, 0.00; loss of thickness of web, 100%.

(B) 7-in. rolled I-beam stringers supporting sidewalk and roadway flooring planks. Original weight 15 lbs. per ft. Original thickness of web, 0.25 in.; present estimated thickness, 0.04 in. (observed thickness in some cases even less); loss in thickness of web, 84%; loss in thickness of flanges, 50%. These floor stringers would be likely to fail by buckling, when subjected to the load of an ordinary wagon.

(C) 10-in. rolled I-beam track stringers (one under each rail). Original weight, 25 lbs. per ft. Original thickness of web, 0.31 in.; present estimated thickness, 0.10 in.; loss in thickness of web, 68%; estimated loss of metal in flanges, 43%. Not safe for electric cars; may fail by buckling of the web.

(D) 24-in. plate girder floor beams, heretofore carrying dead and live loads on each 12-ft. panel length of roadway, consisting of 23½ × ⅜-in. web and four 5 × 4 × ⅝ in. angles as flanges. Original thickness of web, 0.37 in.; loss of thickness of web, 57%; present thickness, 0.16 in.; loss of metal in flanges, 0.28%. Remarks: Too little metal in flanges to carry with safety even an electric car on one track, without other live load on roadway. Because of the diminution in web thickness, the probability of the failure of the beam by the buckling of the web may be even greater than that due to the failure of the flanges under the compressive or tension stresses that might be developed by a loaded electric car.

(E) Bottom chords of trusses. These consist of six parallel bars, the lightest being 3½ × 15-16 ins. each. The loss of available metal section of these bars is estimated at 27%. These bottom chords would be safe in their present condition for ordinary vehicle traffic, but would be stressed beyond the safe limit if loaded electric cars were also allowed to use the bridge.

Ineffectiveness of Paint as a Metal Protector Over Tracks.

The paint applied to the upper chords of these bridge trusses two years ago, beyond the effect of the locomotive exhaust, has protected the metal from oxidation because the paint here has been exposed to only the effect of ordinary weathering, but the condition of the steel work below the bridge floor, where it has been exposed to the direct action of the locomotive exhaust discharges, shows the degree of structural disintegration of paint as a protective agent under such conditions. The effectiveness of the locomotive exhaust in removing paint from metal surfaces may be understood when it is considered that the exhaust steam and hot air carries with it a mass of hot cinders and fine particles of coal, which, when impelled with high velocity, act in the nature of sand blast on objects with which they come in contact. This mechanical action of the discharge, combined with the chemical action of the gases therein removes the paint soon after it is applied and thus leaves the metal work exposed to the destructive agents from the locomotive exhaust.

It may be shown that the destructive effect on the metal work of the McCallie Ave. bridge of the exhaust from the locomotives using those switch tracks is vastly greater, probably a hundred times, than if the same tracks were through lines used only by the regular departing and arriving freight and passenger trains.

In the recommendations for rebuilding, the City Engineer advises one of two things: Either to replace the two 120-ft. trusses with two 100-ft. steel girders, completely encased in concrete, or, to renew all of the steel work of the present trusses except the upper chords, replacing all steel stringers but those under the street railway tracks with timber and covering all exposed steel work, that is, the lower chords, track stringers and floor beams, with concrete. The method to be adopted has not been decided upon.

An interesting legal complication has arisen as a result of the necessity for rebuilding the bridge. It seems that the bridge was built under the joint responsibility of the County of Hamilton, in which Chattanooga is located, and the railways passing under the structure. Immediately after completion, in May, 1905, the territory in which the viaduct is located was annexed to the city and the city authorities took over with the new territory this bridge, with the design and erection of which they had no connection. Now, by a state statute passed in 1907, the city of Chattanooga has authority to require the railroads within its boundaries "to build, maintain, repair or replace, at their own expense . . . bridges . . . over their tracks when the same cross any of the streets of the city, as the General Council may deem necessary to the safety and convenience of the public . . ." Under this statute it seems probable that the city will proceed against the railways for the cost of reconstruction, although so far as the design of the bridge shows, neither the railroads or the city made any effort to protect the steel from the locomotive fumes.

The Rateau Centrifugal Air Compressors and Blowers.

By FRANK KOESTER,* Assoc. Am. Inst. E. E.

The development of the old familiar fan, capable of maintaining an air pressure of only a few ounces per square inch, into the positive pressure blowers favorably known in this country, needs no discussion here. It has not been possible, even with this, however, to efficiently maintain a pressure of more than a few pounds per square inch. The system of blowers and compressors invented by Prof. A. Rateau, of Paris, France, has proven a great advance and this machinery, as now made by Brown, Boveri & Co., of Baden, Switzerland, who have acquired the Rateau rights, represents the latest development in compressor practice. This machinery seems likely to replace the reciprocating compressor and blower to a large extent, especially where heavy-duty machines are required.

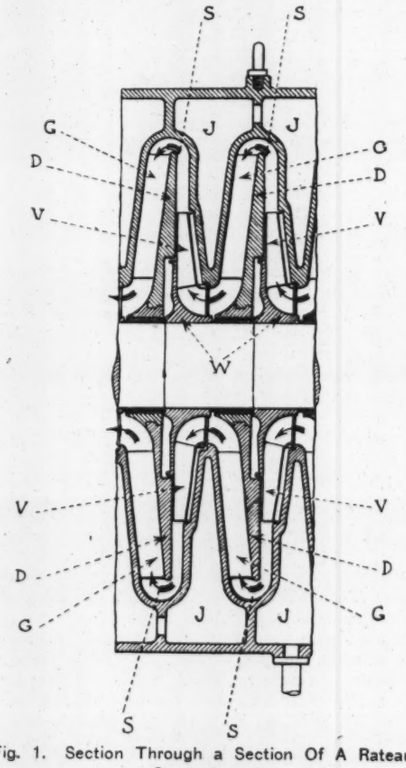


Fig. 1. Section Through a Section Of A Rateau Compressor.

*400 West 57th St., New York City.

A distinction has been made by the inventor between "blower" and "compressor," though the essentials of design are not different for both. When a blower is operated for a normal gage pressure of 20 lbs. or over, it is termed a "compressor."

The Rateau turbo-compressors and blowers are of what might be called single or multiple cylinder types and are water jacketed or not, according to the volume and pressure of air required. The general principal involved in this design consists in using a high-speed impeller encased in a cylindrical chamber, for drawing in the air and discharging it at its periphery into the distributing system whereby, in losing its velocity, the kinetic energy of the air is converted into potential energy in the form of air under pressure. Fig. 1 shows, in cross section, a portion of a water-jacketed compressor. W indicates the propeller wheel and V the vanes of this. G marks the stationary vanes forming a part of the impeller chambers; D is a diaphragm of the chamber and S is the annular distributing space; J is the water jacket. The diaphragms are provided with stuffing boxes. The whole design much resembles the more familiar multi-stage centrifugal water pumps.

It is seen that by making use of a number of impellers, each of which adds a certain increment of pressure to the air drawn in, it is simply a matter of multiplication to produce any desired pressure of air.

As manufactured by Brown, Boveri & Co., the units are single cylinders with either single or double suction inlet, as seems best. In some cases, to accord with permissible speed of prime mover, several units are coupled together and connected in parallel or series, as shown in Figs. 4 and 5.

The cylinders are made of a special cast-iron alloy and are divided in halves, longitudinally, as with Parsons turbines. This is shown in Fig. 5. The cylinders for blowers are seldom water jacketed, but those of the compressors (operating at pressures exceeding 20 lbs. per sq. in.) usually are so designed. Water cooling, in some instances, is extended to the diaphragms also, these being then made hollow. Thus the air throughout its course is in contact with large cooling surface and consequently, at high pressures, the efficiency is considerably increased as the compression curve approaches more closely to an isothermal.

In the single cylinder construction the double suction is used (Fig. 3), except in small units, in order to eliminate the thrust upon the bearings. The same result is obtained in the double cylinder type by arranging the suction between the two cylinders or at their opposite ends. The last distributor, of which the delivery pipe forms an extension, has the form of a volute, with gradually increasing cross-sectional area.

Where more than one cylinder is employed these are mounted on a common bed-plate with a bearing between the cylinders. With such multi-cylinder compressors, the size of the impeller chambers, and of course the diameter of the impellers, decreases in each cylinder to correspond with the decrease of the volume of air.

The stuffing boxes in the diaphragms through which the shaft passes are of babbitt or other soft

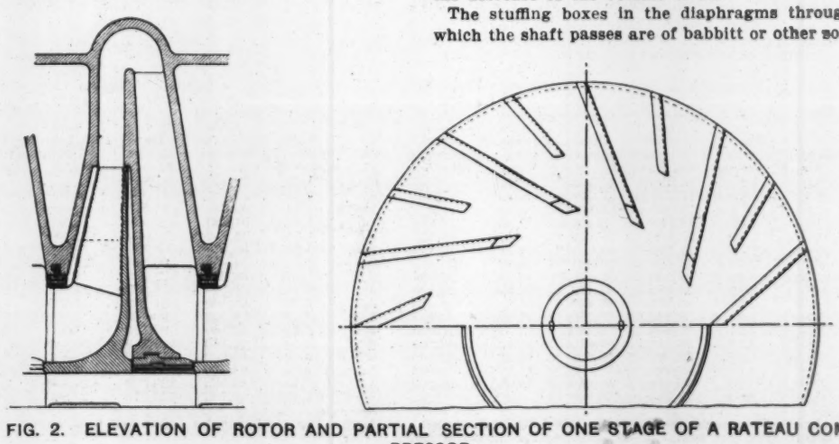


FIG. 2. ELEVATION OF ROTOR AND PARTIAL SECTION OF ONE STAGE OF A RATEAU COMPRESSOR.

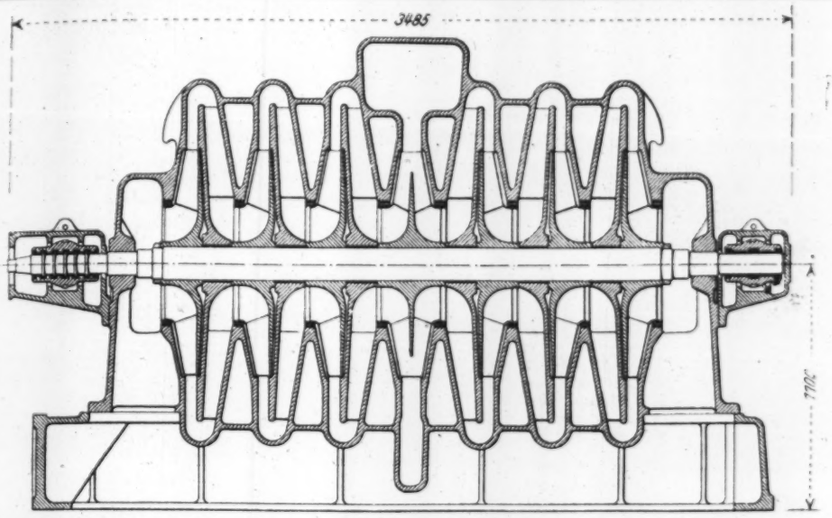


FIG. 3. CROSS SECTION OF A RATEAU, SINGLE-CYLINDER, DOUBLE-SUCTION BLOWER WITH COMMON CENTRAL DISCHARGE.

metal. As they sustain no weight, lubrication is not necessary. The bearings of the shaft are of the usual spherical-seated type, lined with babbitt metal. Those for small units have oil rings, while oil under pressure is supplied to the bearings of the larger sizes.

Two-cylinder machines are provided with three bearings, the one between the cylinders being double, while a three-cylinder machine has four bearings, two of which are double. One or two of these are thrust bearings, to carry any slight unbalanced axial thrust which might occur.

The impellers are built up on a body of forged steel to which the vanes, made of specially selected nickel-steel, are securely riveted. The vanes are further secured by nickel-steel stiffening rings. Tests have shown that blowers and compressors with this construction of vanes may be safely operated at a peripheral speed of 32,000 ft. per min. The impellers are forced upon a nickel-steel shaft and keyed.

The blowers have short shafts and there is no trouble in keeping them large enough to give ample strength and yet small enough to reduce the leakage of air at the stuffing boxes to a minimum. In the compressors this is hardly possible with the long shafts necessary. Here the diameters are so fixed that they rotate considerably above a critical-speed point and, being somewhat flexible, automatically adjust themselves to the true axis and rotate about the center of gravity.

In many instances, particularly in the case of blowers for supplying air to cupolas where it is desired to maintain a constant volume, an automatic regulator operating a governor on the prime mover is placed on the delivery pipe. This regulator is, in fact, a Venturi meter for air. A small difference of pressure is produced between the end and throat, the amount of which changes for different air flow. This change is sufficient to actuate the prime-mover governor. As the blower pressure is proportional to the square of the speed, a relatively small variation in the latter is sufficient to change the blower pressure so as to keep a fairly constant flow of air. The volume of air furnished to a furnace, for instance, can be kept within 5% above and below the normal working value in spite of changes in furnace resistance.

On the other hand, in connection with turbo-compressors, it is often desirable to keep the pressure constant irrespective of the volume of air delivered. This is readily accomplished by the use of a small air cylinder and piston, controlled by spring or weight and acting upon the governor of the prime mover by link gear. This so regulates that no considerable rise in pressure will take place, even when the supply of air is suddenly cut off.

In cases where turbo-blowers or turbo-compressors operate in parallel with reciprocating blower or compressor units, specially constructed, automatic-relief valves are inserted in the delivery pipe of blower or compressor, which prevent any undesirable exchange of air between the various machines working in parallel.

These compressors and blowers are all preferably driven by horizontal turbines or electric motors, which are coupled directly to their shafts.

The performance of these machines are shown in Figs. 8, 9, and 10. Fig. 8 shows curves made from tests on a blower discharging 700 cubic meters (24,724 cu. ft.) of free air per minute, at 0.7 atmosphere (10.3 lbs. per sq. in.), driven by a Brown, Boveri-Parsons steam turbine. Two blowers like this are installed in the works of Bolkan, Vaughan & Co., Middlesborough, England. This figure shows the relations of pressure, efficiency and absorbed power to air discharge for three speeds, 2,350, 2,650 and 2,950 r. p. m.

Fig. 9 shows the results of a number of tests on the compressor of Fig. 4. This is a 325-HP. set delivering 2,120 cu. ft. of free air at 50 lbs. pressure, running at a speed of 4,000 r. p. m. in the works of Brown, Boveri & Co. It was on account of the particularly favorable performance shown by these tests that this firm definitely acquired license from Prof. Rateau for the manufacture of machines after his system.

Fig. 10 shows the variation between pressure and volume of a 600-HP., constant-pressure blower at the Rote Erde smelting works, Aix-la-Chapelle, Germany. The five curves reproduced represent tests at five speeds.

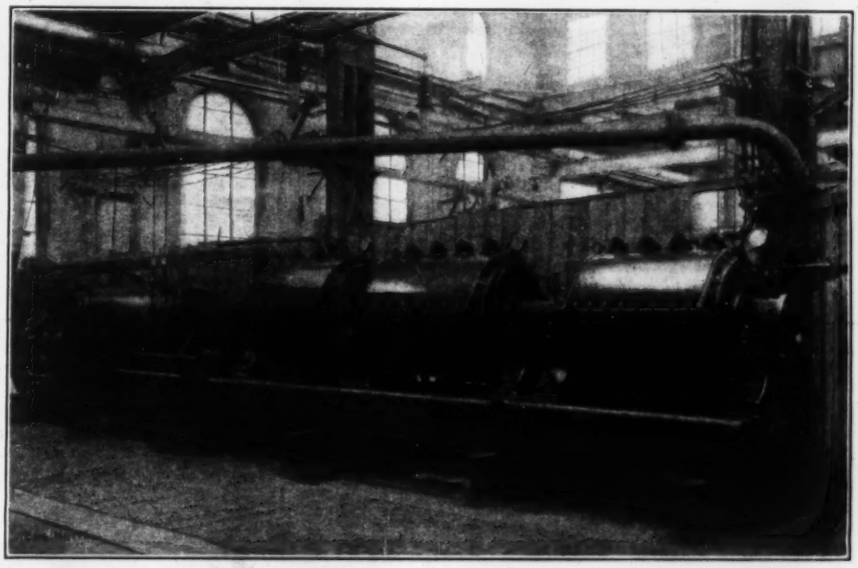


FIG. 4. A 325-HP. TURBINE COMPRESSOR SET, IN THE WORKS OF BROWN, BOVERI & CO., BADEN, SWITZERLAND.
(Capacity of 2,120 cu. ft. per min. of free air, at 50 lbs. per sq. in.; speed, 4,000 r.p.m.)

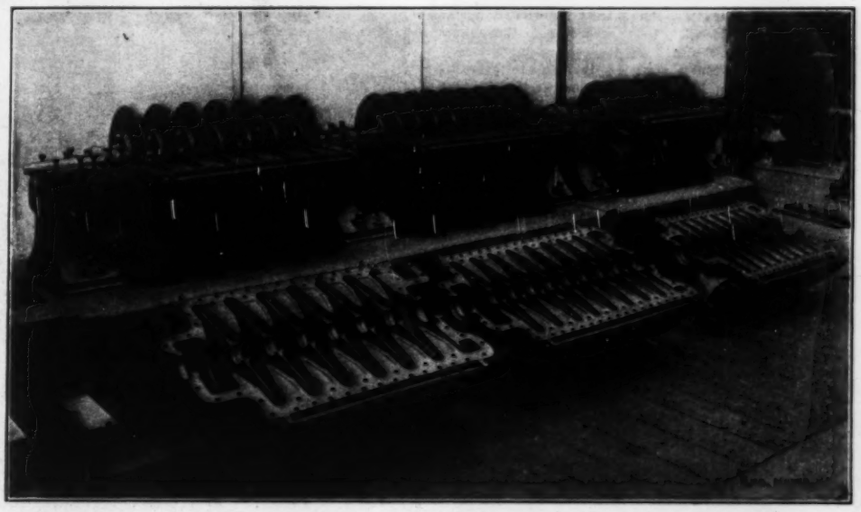


FIG. 5. A THREE-CYLINDER RATEAU COMPRESSOR; UPPER HALF OF CASING REMOVED.

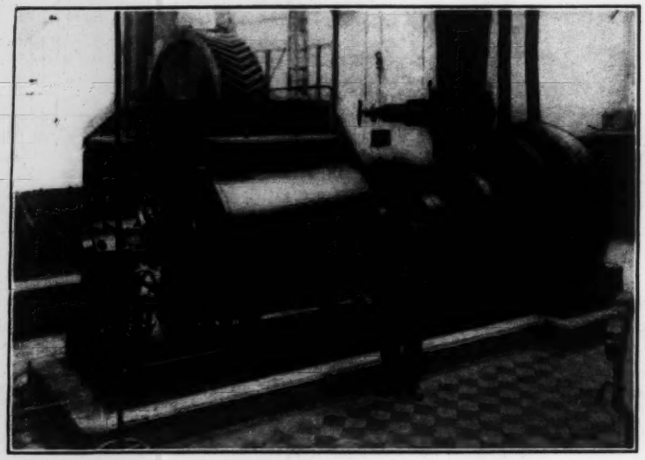


FIG. 6. A 650-HP. MOTOR-DRIVEN BLOWER.
(Delivering 22,000 cu. ft. of free air at 4.5 lbs. pressure. Deutscher Kaiser iron works in Bruckhausen, Germany.)

The advantages claimed for these machines over reciprocating types are many. Briefly stated they are as follows:

(1) Smaller weight and smaller space required, reducing the cost of foundations, of handling, etc.

(2) Absence of all reciprocating parts, of valves, packings, etc., exposed to wear and subject to deterioration; reducing the cost of repairs and eliminating vibration.

(3) Slight attention required, one man being able to attend three or four units.

(4) Reduced consumption of oil and other supplies.

(5) Continuous and steady delivery of air, with great flexibility of operation; automatic accommodation of varying requirements of furnaces and similar apparatus; maintenance of fixed relation of volume and pressure.

(6) Utilization of exhaust steam from large reciprocating engines, by using a low-pressure turbine.

(7) The efficiency of these machines compares very favorably with that of the best reciprocating compressors or blowers.

(8) The blowers are ideal for cupolas, blast furnaces and converters. The compressors are admirably adapted for operation of pneumatic tools and machinery.

The use of these machines is not confined to the supply of air. Fig. 7 shows a blower in the Berlin (Germany) Gas Works for forcing illuminating gas through the mains at a pressure of 17.5 lbs. per sq. in. This unit has a capacity of 16,600 cu. ft. per min. at this pressure. It is driven by a 156-HP. Brown, Boveri-Parsons turbine at 3330 r.p.m.

RAILWAY ACCIDENTS IN MASSACHUSETTS during the year ending June 30, 1909 according to the annual report of the State Board of Railroad Commissioners, killed and injured 271 persons less than in the preceding year. In the year 1908-9, 250 persons were killed and 579 were injured; in 1907-8, 291 were killed and 809 were injured. The report shows that throughout the State there are 1,821 grade crossings, nine less than the number given in the report for the preceding year, and the number of persons killed at grade crossings was 22 as compared with 27 for the year 1907-8.

METAL PRODUCTION IN 1909.—The U. S. Geological Survey has published bulletins of its collections of statistics and estimates on the metal industries of the country for the year just closed. From these the following figures are taken.

There was a strong revival in the iron industry during 1909. The production of ore and pig nearly reach the figures for 1907, which was the year of maximum production yet reached. The figures for 1907, 1908 and 1909 are as follows:

	1907. Reported.	1908. Reported.	1909. Estimated.
Pig iron	25,781,361	15,936,018	25,500,000
Iron ore	51,720,619	35,983,336	51,000,000

The output of pig increased gradually with a slight halt in February and April only. On June 30, 1909, out of a total of 463 blast furnaces 258 were in blast, as compared with 236 on Dec. 31, 1908. By Nov. 1, the number had increased to 309 and by Dec. 1 to 314. The increase in iron ore production was distributed all over the country though greater proportionally in the Lake Superior district than elsewhere.

The output of copper from all copper mines in the country in 1909 surpassed all previous records. Figures based on eleven months' reports and an estimate for December show that the output of blister and lake copper was 1,117,800,000 lbs. against 942,570,721 in 1908. This is an increase of 18%. Montana again ranks first in output, followed by Arizona, Michigan, Utah, Nevada and California. The production of refined copper, from all sources, domestic and foreign, is placed in excess of 1,400,000,000 lbs., compared with the 1,161,176,000 lbs. of 1908. Mine development has been active in most of the important camps, but especially so in the deposits of disseminated ore in Arizona and Nevada. The mines and the smelters of the country are now in a position to make the output of 1910 larger than that of 1909.

The total production of refined lead, desilverized and soft, from domestic and foreign ores in 1909 was approximately 444,363 short tons, worth at the average

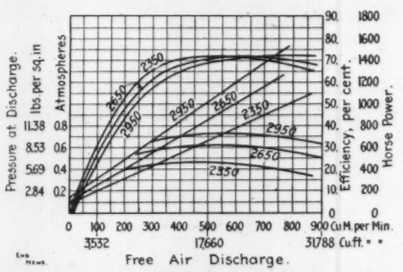


Fig. 8. Characteristics of a Rateau-Brown-Boveri Blower.
(Rated as discharging 24,700 cu. ft. free air at 10.3 lbs. per sq. in.)

New York price $38,215,000, as compared to a production of 396,433 tons in 1908 and 414,189 tons in 1907. These figures do not include an estimated output of 12,880 tons of antimonial lead, as against 13,629 tons in 1908 and 9,910 tons in 1907. Missouri apparently retained first rank among lead-producing states.

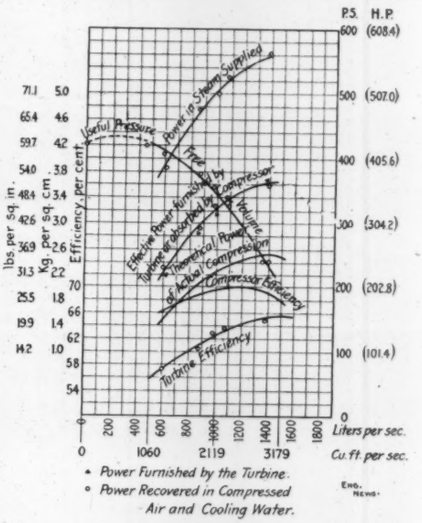

P.S. H.P.
Efficiency, per cent.
lbs. per sq. in.
Kg. per sq. cm.
Liters per sec.
Cu. ft. per sec.
Power Furnished by the Turbine.
Power Recovered in Compressed Air and Cooling Water.

Fig. 9. Characteristics of Rateau Compressor. (From Tests on the Unit Shown in Fig. 4.)

The zinc industry in 1909 had a year of unexampled expansion. Not only was the largest output ever made in the United States almost completely absorbed by the market, but the imports were much larger than ever before. Local accounts indicate a record-breaking production of zinc ores in the Joplin and upper Mississippi Valley regions and from the Franklin Furnace mines of New Jersey. The production of primary spelter from domestic ore in 1909 is estimated at 241,842 short tons, and from foreign ore at 26,373 tons, a total of 268,215 tons, worth at the average price $28,967,220, as compared to 210,424 tons in 1908 and 249,860 tons in 1907.

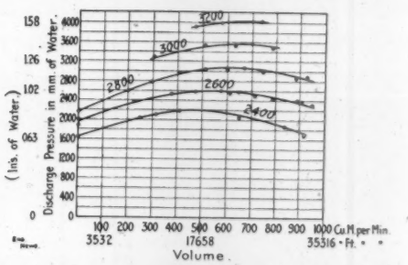


Fig. 10. Regulation Curves of a 600-HP. Constant-Pressure Rateau Blower.

FIG. 7. A 156-HP. RATEAU BLOWER FOR BOOSTING GAS PRESSURE.
(Mariendorf station of the Berlin Gas Works.)

A Large Gasoline Motor Car for the Oregon Short Line Ry.

Gasoline motor cars with direct chain transmission from the crank shaft to the driving axle were introduced on the Union Pacific Ry. a few years ago by Mr. W. R. McKeen, Jr. (then Superintendent of Motive Power). They proved to be so successful that a number of other roads used them for branch line and local service. The business prospects were so good in this direction that Mr. McKeen resigned from the railway and organized the McKeen Motor Car Co., which has works at Omaha, Neb.

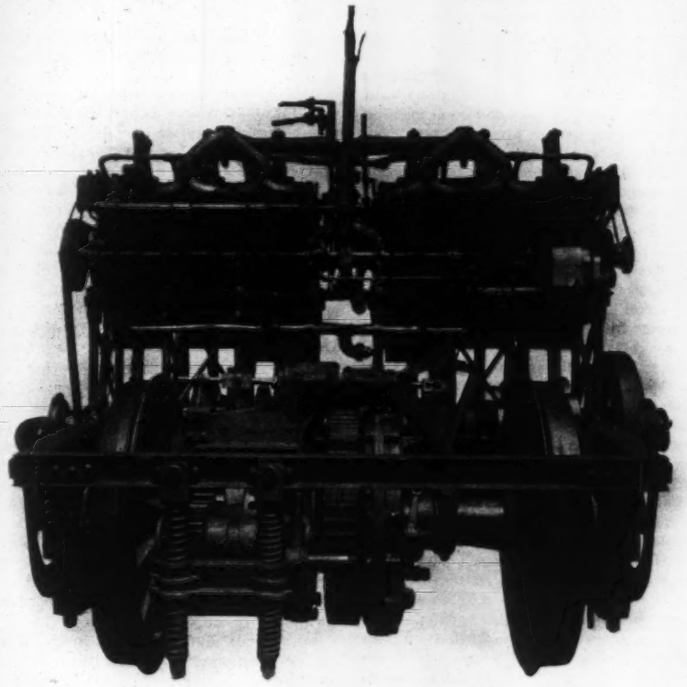


FIG. 1. FRONT VIEW OF TRUCK OF McKEEN GASOLINE MOTOR CAR, SHOWING THE ARRANGEMENT OF THE ENGINE AND DRIVING MACHINERY.

Up to the present time 59 cars have been built, all of which are in service in the United States or Mexico. About 24 railways are operating or have ordered cars of this type, and six railways have ordered additional cars as a result of their experience. The St. Joseph & Grand Island Ry., for instance, after using one of the 55-ft. cars, placed an order for five of the 70-ft. cars, with which it proposes to handle practically all of its passenger business. Particulars of some of the earlier and smaller cars have been published in our issues of April 6 and Dec. 21, 1905; Nov. 22, 1906, and Nov. 7, 1907.

While motor cars with various arrangements of motive power have been introduced, the McKeen type of car with a direct mechanical drive from the gasoline engine to the axle has proved both reliable and economical in somewhat extended service. The economical and efficient results in operation are considered to be due largely to the simplicity, accessibility and strength of the engine, the transmission gear, and the controlling apparatus.

One of the latest of these motor cars has been built for the Oregon Short Line Ry., to operate the Malad Valley branch, between Ogden and Malad (Utah), 52 miles. It is a 70-ft. 34-ton car, seating 64 passengers and including all the facilities of a regular train (with baggage, express and mail accommodation). It represents the special features in the design and equipment of the McKeen type of car and these features are shown by the accompanying plan and elevation.

This car has a steel frame with steel sheathing, and a steel roof of the turtle-back shape fitted with exhaust ventilators. The forward end is wedged-shaped (with parabolic curves), while the rear end is semicircular. Side entrances at the middle of the car (having inside steps and doors flush with the sides) lead to a transverse vestibule. At the rear of this vestibule is the passenger compartment, seating 54 passengers and having a toilet room. Forward of the vestibule are the smoking room (seating 10 passengers and having its own toilet room), the baggage and express room, the mail room, and the engine room. The windows are circular, and built like the ports of steamer cabins, but of larger size than the latter.

The car is mounted on two four-wheel trucks. Only the leading axle of the front truck is driven from the engine, and the wheels are not coupled, the trailing axle having wheels of small diameter. The 200-HP. six-cylinder gasoline engine is of special design for this service, and has direct connection from the crank shaft to the truck driving axle by means of a Morse silent chain which is said to give an efficiency of 96% in the transmission. The cylinders are 10 × 12 ins., water cooled, and jacketed with ⅛-in. copper. They are cast in sets of three, and mounted on a single cast-steel frame. The engine is started by compressed air and is reversible. Being mounted on the truck frame it is independent of the car body and relieves the car from vibration.

The bed-plate or frame of the engine is a steel casting mounted on the truck frame, and all shock or jar is absorbed by journal-box coil springs. Elliptical springs on the truck bolsters support the car body, and these in combination with the coil springs free the car from disagreeable vibration due to defective conditions of the track.

Fig. 1 is a front view of the truck and the driving machinery. Each crank of the crank-shaft is counterbalanced, and the two halves of the shaft (three cylinders to each half) are secured together by the driving or crank-shaft sprocket. The drive from the shaft is by means of a Morse silent chain, 5 ins. wide, driving the sprocket which is attached to the friction clutch. The friction clutch revolves free on the main driving axle, and when engaged the friction clutch hub plate (which is integral with the high-speed clutch gear), revolves as a unit.

The power is transmitted to the main axle by an "octoroon" sliding clutch. This slides on the axle, which has a hexagon fit, no keys or feathers being used. The clutch has specially designed teeth, of such shape that they assist in engaging and disengaging with the teeth of either the high or low speed gears, when the sliding "octoroon" is operated. Both the friction and "octoroon" clutches are operated by air cylinders, controlled by a valve located on a pedestal convenient to the motorman.

The low-speed gear, which is used for starting, is an indirect drive to the main axle driven by means of back gears. In the high-speed or regular running position, the "octoroon" clutch is engaged with the high-speed gear, which is integral with the friction clutch and the entire transmission revolves as a single unit.

In the plan of the engine room shown in Fig. 2, (A) is the engine, (B) a cabinet for the storage batter and tools, (C) the sandbox, (D) the auxiliary air compressor, (E) trap doors for access to the mechanism on the truck, (F) the motorman's seat, (G) a pedestal for the brake and clutch actuating valve, (H) the hand brake.

The water circulating system for cooling the cylinders consists of a rotary circulating pump, cooling coils inside the pilot and at the rear of the car, an expansion tank, and heating coils inside the car. In warm weather, the water is circulated through the outside cooling coils, and in cold weather it is circulated first through the inside coils for the purpose of warming the car. Adjustable exhaust ventilators are fitted in the roof, while fresh air is admitted by inlets at different parts of the floor. The car is lighted by acetylene gas stored in a tank under the rear end.

The main supply of gasoline is carried in a 120-gal. tank (J) attached to the underframe. From this the gasoline is delivered to an auxiliary tank

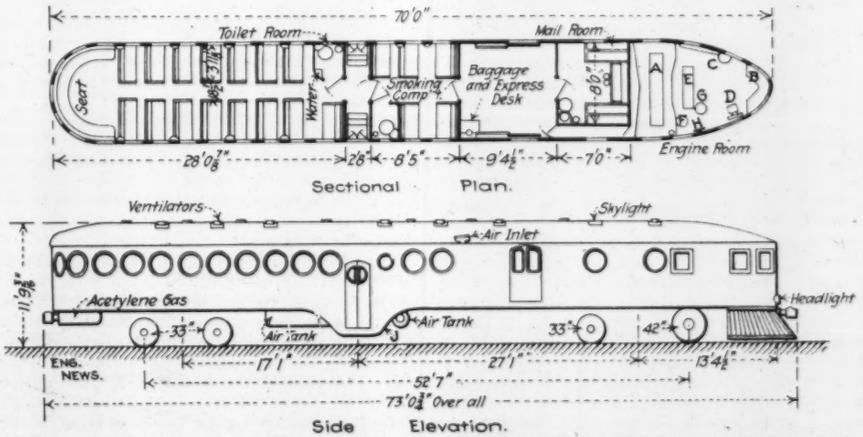


FIG. 2. PLAN AND ELEVATION OF 70-FT. 200 HP. GASOLINE MOTOR CAR FOR THE OREGON SHORT LINE RY.

(McKeen Motor Car Co., Omaha, Neb., builder.)

in the engine room, and from this it flows to the McKeen automatic carburetor on the engine. The compressed air for starting the engine, operating the clutch and brakes, and sounding the whistle, is supplied by a pump driven from the engine and is stored in three seamless steel tanks attached to the underframe. There is also in the engine room an air compressor (D) driven by a gasoline engine. Automatic M. C. B. couplers are fitted at each end.

The underframe is of steel I-beams and channels, with cast-steel body bolsters, each bolster being a single casting. The upper framing is largely of 2-in. grooved steel and 3-in. and 4-in. channels, with 1/8-in. sheet steel sheathing and roof. The floor is of 13/16-in. hard maple on noiseless sheet steel flooring. The headlining is of pressed board, formed to fit the curves of the round or turtle-back roof. The interior finish is mahogany. The mail room is equipped with standard shelves, pigeon-holes, pouch racks, etc., and has a closet, washbasin and water tank, so that the mail clerk is independent of the rest of the car. A corridor leads from the baggage room to the engine room.

The general dimensions of the car are as follows:

	ft.	ins.
Length over end sills	70	0
Over couplers and pilot	73	0¾
Passenger compartment (54 pass.)	28	0⅞
Vestibule	2	8
Smoking room (10 pass.)	8	5
Baggage and express room	9	4½
Mail room	7	0
Engine room	13	8
Width over side sills	9	8
Width inside	9	4¾
Width over all	10	2¾
Height, rail to top of roof	11	9 31/32
Height, floor to ceiling at center	7	5⅝
Driving wheels (2), steel tires	3	6
Carrying wheels (2 on front truck, 4 on rear truck), rolled steel	2	9
Wheelbase, front truck	9	5
Wheelbase, rear truck	7	0
Spacing between truck centers	44	2
Weight in working order	68,000	lbs.

The Presidents of Four National Engineering Societies.

(With inset sheet of portraits.)

In accordance with our annual custom, continued now for seventeen years, we present to our readers with this issue portraits of the Presidents of the four great National engineering societies, with biographies of the professional career of each.

John A. Bensel, President of the American Society of Civil Engineers.

By J. WALDO SMITH and PROF. WM. H. BURR.

The engineering profession has produced many prominent men of widely varying characteristics; all successful as professional men, and yet with individual equipment qualifying for various parts of the wide field covered by the profession. It has at times been a moot question among engineers themselves whether members of their profession should, as professional men, hold administrative positions. The recently elected president of the American Society of Civil Engineers is a man whose activities throw strong light upon this question.

John Anderson Bensel was born in the City of New York on August 16, 1863. His early education was received both in public and private schools of the city and prepared him for entrance to the Stevens Institute of Technology at Hoboken, where he graduated with the class of 1884. Although Stevens Institute is pre-eminently a school of mechanical engineering, he indicated a decided turn toward the work of the civil engineer by immediately on his graduation taking service as an assistant engineer in the field organization of the Aqueduct Commissioners of the City of New York. This service extended over less than a year, when he left that work for a position with the Pennsylvania Railroad Co. His first assignment with this company was that of rodman, after which he was promoted to assistant engineer and finally attained the rank of assistant supervisor of the New York division. This service extended over nearly four years and gave him an introduction to what was then, and probably has been ever since, one of the best railroad engineering organizations in the world and this connection doubtless exerted its influence on Mr. Bensel's subsequent career.

His chief work, however, prior to his present connection with the Board of Water Supply, has been on the design, construction and administration of the largest water front interests in this country, viz.: those of the City of New York. His first engagement in this field was that of assistant engineer in the Department of Docks in 1889. From this position, during six years of service, he rose through the various grades in this department to the position of assistant engineer in charge of construction. While engaged on this work his experience covered practically all the branches of design and construction of water front structures found about the harbor of New York. The enormous ocean traffic of that port requires for its suitable accommodation works capable of providing facilities for the effective and economical handling of passengers and cargoes, not only from the largest ships afloat, but also for the extraordinary number of vessels which each year arrive at and depart from the port.

Up to this point his engineering experience covered effectively his participation in the design and construction of works in the fields of railroading and harbor works, and it was in the natural course of his development, therefore, that he began an independent career of engineering and construction work which he followed for two years. He was retained on many prominent water front and harbor works and in other fields of practice. While acting as consulting engineer for the City of Newburgh, it became his duty to make a valuation of water front property in a suit instituted against the Pennsylvania Coal Co.. This work was so thoroughly and effectively done as to attract the attention of the Supreme Court which adopted his valuation in its decision.

Another prominent work accomplished by him while engaged in private practice was that for the Girard estate in Philadelphia. That estate enjoys possession of valuable water front property on the Delaware River for which he designed and executed large improvements.

In 1898 Mr. Bensel became engineer-in-chief of the Department of Docks and Ferries of the City of New York. This was practically at the beginning of the era of modern water front improvements and under his direction practically all of the Chelsea Docks, as well as extensive works on the water front of Brooklyn, were designed and constructed. After having served as Chief Engineer for seven years, he was appointed commissioner of the department, which position he held for about two years. During his connection, therefore, with the Department of Docks and Ferries of the City of New York, he not only executed some of the largest harbor works ever built in this country, but he also carried through the transfer and the reorganization of the Staten Island Ferry from the unsatisfactory old service given by a private company to that with its present new type of commodious ferryboat, owned and operated by the city. These works required both the application of a high degree of engineering skill, and the exercise of unusual executive and administrative ability, and it is in this direction that he represents the most effective development of the modern engineer.

After having successfully administered the interests of the Department of Docks and Ferries, he was made President of the Board of Water Supply in January, 1908. The Board of Water Supply was created by an act of Legislature in June, 1905, for the purpose of constructing a system of additional water supply for the city of New York. This water is to be taken from the Catskill Mountain region to an amount of not less than 500 million gallons per day, and the work involves the construction of about 92 miles of aqueduct from the Ashokan reservoir in the Catskills to the northerly limit of New York City. It includes also the Kensico and Hill View reservoirs, as well as a filtration plant to be eventually constructed a short distance south of Kensico reservoir. South from the Hill View reservoir, which has been designed to serve as an equalizing basin, heavy aqueduct construction is also required for the purpose of introducing the new water supply into the present distribution systems of all the boroughs of the city. The plan now contemplated includes the construction of a deep rock tunnel beneath the Borough of the Bronx, under the Harlem River, in a generally southerly direction to the lower end of Manhattan, and thence under the East River to the heart of the Borough of Brooklyn, from which point it will be led through metal pipes to the Borough of Queens, as well as to the Borough of Richmond through a pipe crossing at the Narrows.

The administrative work of the President of the Board of Water Supply is thus seen to be of great extent and to involve responsibilities of unusual weight, the total expenditure contemplated on this work reaching to over $160,000,000.

As already intimated, Mr. Bensel's career has exemplified in a marked manner the capacity of the engineer as an executive and administrator. The development and administration of those parts of municipal government which involve the care, maintenance and operation of large public works require both the training and the professional experience of the civil engineer. Mr. Bensel's life work has been such as to make him familiar with the general character and the details of the public interests to be served, and the whole trend of his development as an individual has been to make him both direct and effective in dealing with such interests. It is his belief that the engineer of to-day has not attained the prominence to which he is entitled by the character of his work, and that in order to reach this prominence the courage which comes from a proper appreciation of the engineer's obligation to the profession, as well as to the work upon which he is engaged, is necessary. This courage, he believes, is a prerequisite to the attainment of the fullest success. There have been a number of civil engineers in the United States who have demonstrated by their successful work the truth of these observations and prominent among them stands Mr. Bensel.

George Westinghouse, President of the American Society of Mechanical Engineers.

By ARTHUR WARREN.

The American Society of Mechanical Engineers at its annual meeting, held in December, elected Mr. George Westinghouse as its President for the ensuing year.

Mr. Westinghouse has so long been well known, not only to the engineering profession, but to the world in general, that many persons who are unacquainted with him seem, naturally enough, to think him a much older man than he is. For forty years he has been famous as an engineer, inventor, and manufacturer, his name being familiar in all parts of the world, wherever railroads run and electric currents are generated. But his first great success, the air-brake, gave him renown when he was only twenty-two.

Mr. Westinghouse is now only a little over 63, and is in the fullness of his powers. He was born Oct. 6, 1846, at Central Bridge, Schoharie County, N. Y. His parents were George and Emeline Vedder Westinghouse. George Westinghouse the father removed to Schenectady in 1856 and engaged in the manufacture of agricultural machinery. His son, George, obtained his early mechanical experience in his father's shops which he haunted whenever his school duties permitted.

At the age of 15 he gave evidence of the direction in which his future successes were to be achieved by inventing a rotary engine.

He enlisted in June, 1863, as a volunteer in the Union army. He had not reached 18, the minimum age for enlistment; in fact he was not 17. But he stood six feet in his stockings and weighed 180 lbs., and the recruiting officers never asked him how old he was, taking it for granted that he must be, as indeed he looked, older than the minimum age for recruits.

He joined the 12th New York Infantry, enlisting for thirty days. When his time had expired, he enlisted again, on this occasion with the 16th New York Cavalry, with which he remained until November, 1864. Then, having passed the requisite examination, he joined the Engineer

Corps of the Navy, and served as an Assistant Engineer, U. S. N. from December, 1864, to August, 1865. Hostilities being concluded, and the war force reduced to a peace basis, he returned home, and entered Union College, passing his examinations with such distinction that he entered the sophomore, not the freshman, class. In the same year he invented a device for replacing derailed cars on the track.

While seeking to introduce this device to railway companies, the idea occurred to him of inventing some form of railway brake to be operated by the engineer. The frequency of accidents, the waste of life, limb, property, labor, and time due to the methods then employed made a deep impression upon his mind. In 1868 he invented and patented the air-brake, thus, as a very young man, achieving great distinction. On the trial trip of the first train equipped with the air-brake, the prompt stoppage of the train prevented an accident and probable loss of life.

The air-brake, with the numerous improvements and developments which Mr. Westinghouse has added to it, has revolutionized railway operation. Although popularly regarded as purely a safety device, it is far more than that. By placing a train under control of the engineer, it has made high speed possible, increased the frequency of service, enabled larger cars, longer trains, and heavier loads to be carried and has made possible great economies in the cost of transportation. For all these reasons it has been of incalculable benefit to mankind.

Having produced the air-brake, Mr. Westinghouse next turned his attention to the development of switching and signaling systems. Here again he originated pneumatic devices, and later he combined these with the electrical operation of signals and switches. This work successfully established, he carried electrical experiments still farther, and, as if foreseeing the vast developments of the new industry that was to come, he took up the subject as thoroughly as he had taken up its predecessors. His faith in electricity was as great as his faith in the ability to control train movements by air. When others were sceptical, he became the champion of the alternating current.

In 1885 he acquired the patents of Gaulard & Gibbs, and directed his energies to the development of machinery for the generation, transmission and use of the alternating current. Against an opposition which now seems incredible, so powerful and mistaken did it prove to be, seeking as it did in many states legislation prohibiting the use of this current, he succeeded in introducing the alternating system and in securing its general adoption. He gave Tesla financial aid, and encouraged him to develop the induction motor, which enabled the alternating current to be used for power purposes. This development was worked out in the Westinghouse shops at Pittsburg.

Mr. Westinghouse followed the discovery of natural gas upon his own land with the invention of a complete system for controlling the flow and conveying natural gas through pipes over long distances so that it was used for fuel in the homes and manufactories of Pittsburg. He experimented for a number of years with his gas-engine for driving electric generators, with the result that he produced, at a time when it was most needed, an internal combustion engine of large power which was completely successful. With the same purpose—the advancement of the electrical art—he brought the Parsons steam turbine to America, incorporated with it improvements of his own devising, and later on turned his attention to the development of a steam turbine for ship propulsion differing essentially from preceding efforts in that direction. Along with this he supplied all the material aid, including workshop facilities, for the production of the speed reduction gearing recently invented by Rear-Admiral Melville, ex-Chief Engineer, U. S. N., and John H. Macalpine, for driving ship propellers with high-speed turbines.

He built the first ten great electric generators for Niagara, and those for the elevated and subway roads in New York, and for the Metropolitan Railway in London. A catalog of his own inventions and those which he has inspired in his staff, and supervised in his works, would make a considerable volume. He has been too busy a man to present papers before the professional societies, but his work and his works have been productive of many papers from other men through a long course of years.

From early boyhood George Westinghouse has been a constant student of mechanical engineering, and for many years, of electrical engineering. He began in his father's machine shop, out of school hours. His irrepressible energy, his determination to master the theoretical and practical sides of engineering have made him a constant worker ever since. He is a master, too, in the commercial relations of engineering with the modern world, his genius as a manufacturer ranking with his genius as an engineer. In 41 years he has built up the great industries, which, through thirty corporations of which he is President, employing $120,000,000 of capital and 50,000 men, have accomplished so much for the material progress of society. The Westinghouse works at Wilmerding, Trafford City, Swissvale and East Pittsburg, Pa.; at London and Manchester; in France, in Germany, Austria, Italy and Russia, are themselves products of his organizing power and engineering ability. He is personally known to and honored by distinguished men in many countries, for his inventions and industries have often called him abroad. The French Republic and the Kings of Italy and Belgium have decorated him; he was the second recipient of the John Fritz Medal, his old friend, Lord Kelvin, having been the first; the Königliche Technische Hochschule of Berlin has conferred upon him the degree of Doctor of Engineering, and Union College the Ph. D. He was elected an honorary member of the American Society of Mechanical Engineers, of which he is now President; he is one of the two honorary members of the American Association for the Advancement of Science, and is an honorary member of the National Electric Light Association.

In June, 1905, owing to the great unrest throughout the country following upon the disclosures concerning insurance affairs, and the effect upon the general financial situation, the controlling interest in the stock of the Equitable Life Assurance Society was placed in the hands of three trustees, who were given full power to vote it according to their best judgment. The trust deed was for a period of five years, the trustees having power to extend the trust for a further period of five years. The trustees selected were ex-President Grover Cleveland, Justice Morgan J. O'Brien, and Mr. George Westinghouse. This selection met with universal public approbation, and, as a result, the directors elected to the Board of the Equitable Society have been independent men who have commanded general confidence.

Mr. Westinghouse, in 1867, married Miss Marguerite Erskine Walker. They have one son, George Westinghouse, Jr. Their homes, at Pittsburg; at Erskine Park, Lenox, Mass., and in Washington, are centers of liberal hospitality and of delightful family life.

Of the many honors which have come to him during his distinguished career none has been more deeply appreciated by Mr. Westinghouse than his election to the Presidency of the American Society of Mechanical Engineers. It has been followed by tokens of regard from representatives of the various sections of the engineering world who have found the occasion appropriate to an expression of the high esteem which the profession holds for the indomitable energy, the foresight, constructive genius and integrity of one of the greatest engineers of our time.

David W. Brunton, President of the Council of the American Institute of Mining Engineers.

By ROSSITER W. RAYMOND.

From its organization in 1871 to its incorporation in 1905, the American Institute of Mining Engineers was managed entirely by its Council, and the President of the Council was the President of the Institute. Since 1905, the corporation is represented by a Board of Directors, and the President of this Board is legally the President of the Institute. But the technical meetings and publications of the Institute are still managed, as before, by the Council; and the President of the Council is the technical head of the society. This arrangement permits the Institute to honor by election to that office distinguished members whose residence outside of the City or State of New York might interfere with their service upon the Board of Directors of the business corporation.

A conspicuous instance is furnished by the election of the present President of the Council, which illustrates also the wider meaning of the term "American," as used in the name of the society. Many officers of the Institute have been elected from Mexico and Canada, as well as the United States. Richard Pearce, its President in 1889, is an Englishman by birth, and Dr. James Douglas, President in 1899 and 1900, is a Canadian, as is also the distinguished subject of the present sketch.

David William Brunton was born June 11, 1849, at Ayr, in Ontario, Canada, and received his first education as an engineer at the Toronto University. After three years of practice, he took a post-graduate course at the University of Michigan; and in 1875 he established himself in Colorado, where he has been ever since identified with the mining and metallurgical interests of the State. As mining engineer for a pioneer enterprise in the San Juan region, and afterwards in connection with reduction-works at Georgetown and at Clear Creek, he enlarged his knowledge of Colorado conditions; and, after a couple of years as engineer and manager at Silver Peak, Nevada, he returned in 1880 to the former State, to build, in partnership with F. M. Taylor, a stamp mill at Leadville. The firm of Taylor & Brunton has endured ever since, and has become well-known throughout the West—and by far larger achievements than its first mill at Leadville—as will be presently shown.

From 1880 to 1889, Mr. Brunton acted as consulting engineer to various leading mining companies in Colorado, and finally as manager of one of them. But in 1889, he resigned that position, to take charge, as consulting expert, of one side of the long and bitter "side-line" litigation under "the law of the apex" in the Aspen district. At the close of that struggle, he became general manager of the mines of one of the litigant parties, and retained that position until 1893.

It was during this period that, after making suitable agreements with other companies benefited by the undertaking, Mr. Brunton planned and executed the famous "Cowenhoven" tunnel (or, more properly, adit-level), a double-track entry 2.25 miles long, driven under Smuggler Mountain for the drainage, ventilation and transportation of the principal Aspen mines. The special difficulties encountered in driving this level through water-saturated dolomite-sand, and the means by which they were overcome, together with the extraordinary progress (up to 421.5 ft. per month) made in solid ground, attracted much attention from mining engineers; and Mr. Brunton's paper on the subject* received from the Institution of Civil Engineers the honor of a "Telford Premium."† It is worthy of record that this work was performed from start to finish without accident to man or machinery—a result undoubtedly due to the skill and care with which Mr. Brunton planned and supervised all details. In recognition of his arrangements for their comfort and safety, the miners, on the completion of the tunnel, presented to him a large gold medal, which he treasures as of equal value with the "Telford Premium."

Aside from this demonstration of professional and executive ability, Mr. Brunton's reputation as a mining engineer is largely due to his inventions and improvements in the mechanical sampling of ores. He was one of the first to call attention to the defects of old-fashioned hand-sampling, by shoveling and quartering; and his mechanical sampler, first installed at

*The Cowenhoven Adit-Level, Proc. Inst. of C. E., Vol. CXXXI. (1898), p. 289.
†Id, Vol. CXXXVIII. (1898), p. 262.

Denver in 1884, and subsequently improved in details, has been incorporated in a series of "Taylor & Brunton" sampling-plants, extending through Colorado, Utah and Nevada. There are other mechanical samplers in use; but Mr. Brunton is entitled to the credit of a pioneer in this field; and it is only fair to add that his paper on the "Modern Practice of Ore-Sampling," read at the Spokane meeting of the American Institute of Mining Engineers, in October last, recognizes the merits of his competitors, while maintaining the principle upon which accurate mechanical sampling is based. The importance of this improvement will be recognized by all who know the conditions of Western mining, and the extent to which small producers are dependent upon correct determination of the value of their shipments.

Mr. Brunton was one of the first to utilize the electric transmission of power in mining operations. The electric hoist which he designed for the Free Silver Mining Co. at Aspen, Colo., was for many years the largest in existence.

Among Mr. Brunton's contributions to professional literature the following may be named, without exhausting the list:

Proc. Inst. of C. E.: "The Copper Mines of Butte," Vol. 82, p. 271 (1885); "Smelting Processes," Vol. 112, p. 199 (1893); "The Cowenhoven Adit-Level," Vol. 131, p. 289 (1878).

Trans. Am. Inst. of Mining Engineers: "A New System of Ore-Sampling," Vol. XIII., p. 639 (1885); "The Theory and Practice of Ore-Sampling," Vol. XXV., p. 826 (1896); Remarks on electricity in mining, Vol. XXVI., p. 1078 (1897); Remarks on mine-surveying instruments (description of the pocket-transit), Vol. XXIX., p. 952 (1900); "Geological Mine-maps and Sections," Vol. XXXVI., p. 508 (1906); "Modern Practice of Ore-Sampling," Bulletin No. 32, for August, 1909, p. 675; "Modern Progress in Mining and Metallurgy in the Western United States (Presidential Address), Bulletin No. 33, Sept., 1909, p. 837.

Mr. Brunton has also furnished valuable articles to the Engineering and Mining Journal of New York City, and to the proceedings of the Colorado Scientific Society, of which his term as Vice-President ended Dec. 31, 1909.

Like many other accomplished mechanical engineers in active practice, Mr. Brunton has devised many improvements deserving the rank of inventions, which he has not taken the trouble to protect with patents. The following list contains those for which he has received patents:

Patent No.	Title.	Date of Issue.
215,877	Improvements in Revolving Ore-Roasters	May 27, 1879.
216,148	Improvements in Ore-Roasting Furnaces	June 3, 1879.
228,632	Improvement in Leaching Ores	May 25, 1880.
255,258	Mining Pumps	Apr. 4, 1882.
304,259	Ore-Sampling Machines	Aug. 26, 1884.
454,120	Devices for Sampling Ores	June 16, 1896.
508,500	Velocipede Tunnel Cars	Nov. 14, 1893.
515,419	Car Couplings	Feb. 27, 1894.
526,021	Pocket Transit	Sept. 18, 1894.
533,508	Ore-Sampling Machines	Jan. 28, 1896.
692,111	Mine Timbers	Jan. 28, 1902.
759,418	Mine Timbers	May 10, 1904.
837,791	Universal Transit Instruments	Dec. 4, 1906.

Of his numerous inventions, a considerable number have come into general use, the best-known being, perhaps, his "time-sampling" system, his "round-timber framing" system, his "tunnel velocipede," and his "pocket transit." Of the latter,* more than 5,000 are now in use by mining engineers in all parts of the world.

Mr. Brunton's expert work in connection with the litigation at Aspen led to his employment for important legal contests elsewhere, in which he has distinguished himself especially by his thorough preliminary study of facts and his skillful methods of presenting them for the comprehension of judges and juries. In this connection, his system of preparing mine-maps and corresponding models is particularly worthy of praise.† But victories in such contests have, after all, but a transient significance; and the most important and permanent service which Mr. Brunton's work in this field led him to perform for the mining industry at large, was his successful recommendation to great mining companies employing him as adviser, of the permanent engagement of special geological experts, not connected with the management of mining work, for the separate purpose of studying and interpreting the indications developed in such work. This has now become the practice of many large companies, and has resulted in much gain, through the discovery of new ore-bodies; the direction of useful, and the avoidance of useless, exploring-work; etc.

At the present time, Mr. Brunton is the consulting engineer for two great mining enterprises, the Cripple Creek drainage-tunnel (which, after the failure of earlier adventurers, is now successfully advancing in the hands of more skillful and courageous contractors), and the Laramie tunnel, in northern Colorado (which is to traverse for 2.5 miles a granite ridge, for the purpose of diverting 800 cu. ft. of water per second from the Laramie River to the Cache la Poudre Creek.

As a consequence of his wide experience and technical skill, Mr. Brunton has been, at one time or another, the adviser of most of the great organizations engaged in developing the mineral resources of the United States, and has included in his professional journeys a large part of the world, having made examinations on this continent from Alaska to the Argentine Republic, besides traveling through Europe, India, Africa, Australia and New Zealand. Certainly the American Institute of Mining Engineers could not have designated, as a representative, a man of greater professional ability, wider fame or more illustrious, unstained record.

*See "Transactions," Am. Inst. of Mining Engineers, Vol. XXIX., p. 952.

†As to mine-maps, see Brunton's paper "Geological Mine-maps and Sections," "Transactions," Am. Inst. Mining Engineers, Vol. XXXVI., p. 508.

Lewis Buckley Stillwell, President of the American Institute of Electrical Engineers.

By HORATIO A. FOSTER.

Lewis Buckley Stillwell was born in Scranton, Pa., in 1863, being descended in the eighth generation from one Nicholas Stillwell, an Englishman who came to America from Holland in 1638, settling in New Amsterdam. The Civic List of the State of New York shows the family to have been prominent in the affairs of the Province, only one name (Van Rensselaer) occurring more frequently among the members of the Colonial Assemblies prior to the Revolution. For the last century Pennsylvania has been the home of Mr. Stillwell's immediate ancestry.

Mr. Stillwell was prepared for college at the High School in Scranton, and entered Wesleyan University, Middletown, Conn., in September, 1882. At the end of the sophomore year he left Wesleyan and entered the electrical engineering course at Lehigh University, completing this course in 1885. In the autumn of that year he returned to Lehigh to take a special course in mechanical engineering, but his work was soon interrupted by a serious illness.

Upon his recovery he accepted an appointment as Assistant Electrician of the Westinghouse Electric & Manufacturing Co. at Pittsburg. Here he became associated with O. B. Shallenberger, William Stanley and others who, at the time, were doing pioneer work in alternating currents and the next four years were devoted to development work in this highly interesting field, destined to be of such great importance to the electrical industry.

In 1890 he became Chief Electrical Engineer of the company, and in 1895 his duties were further extended to include those of Assistant Manager. From 1892, Mr. Stillwell gave much of his time to the development of the plans for the utilization of the power at Niagara Falls, and following the award of the initial contract for electric generating apparatus to the company which he represented, assumed charge of the construction and installation of the electric plant.

In March, 1897, he severed his connection with the Westinghouse Company and was appointed Electrical Director of the Niagara Falls Power Co. and the Cataract Construction Co. His arrangements with these companies were not exclusive, and while extending and operating the plant at Niagara he acted as consulting engineer for various other power and railway projects, among others, the equipment of the elevated lines of the Manhattan Railway Co.

After completing the installation of the first 50,000-HP. plant in Niagara in September, 1900, he resigned his position with the Niagara companies and removed to New York. In November of the same year he was appointed Electrical Director of the Rapid Transit Subway Construction Co., thus having in charge at that time the electrical equipment of both the elevated railways and the subway system of New York City. After completing the equipment of the elevated lines and the subway, which in the meantime had been extended to Brooklyn, he became consulting engineer to the Hudson Companies, in charge of electric equipment of the four tunnels constructed by that organization between Manhattan Island and New Jersey.

He was a member of the commission formed by the Erie Railroad Co. in 1905 to report upon the electrification of the suburban zone of the Erie lines in the vicinity of New York, and is consulting engineer to the United Railways & Electric Co. of Baltimore, the Lehigh Coal & Navigation Co. and other important corporations.

Mr. Stillwell has always devoted his attention strictly to professional engineering practice. He has gathered about himself a number of carefully selected associates and assistants of exceptional experience and ability. Among these associates are John Van Vleck, who, as is generally recognized, has largely influenced central power station practice in America. From 1888 to 1901, Mr. Van Vleck was designing engineer to the New York Edison Co. and since then has shared responsibility with Mr. Stillwell for the design of the large Interborough plant at 59th St. and North River, the new power plant of the Hudson & Manhattan R. R. Co. in Jersey City, and the reconstruction work in Baltimore.

Another associate is Mr. Hugh Hazelton, who has been prominently identified with electric railways since the advent of the third rail in Chicago at the time of the World's Columbian Exposition.

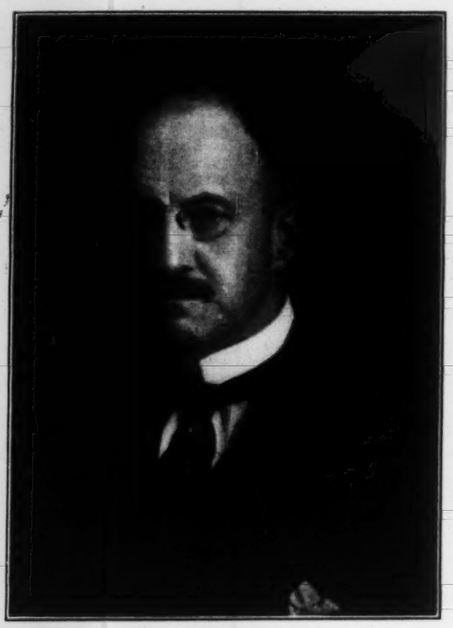
Mr. H. St. Clair Putnam, another associate, was the engineer selected to read the paper "Conservation of Power Resources" at the meeting of Governors called together by President Roosevelt at the White House in May, 1908.

Mr. Stillwell has received the honorary degree of M. S. from Lehigh University and of Sc. D. from Wesleyan University. He is President of the American Institute of Electrical Engineers, a member of the American Society of Civil Engineers, member of the British Institution of Electrical Engineers, member of the American Philosophical Society, member of the British Society of Arts and member of the American Association for the Advancement of Science. His clubs are the Century Association, the Lawyers Club, Railroad Club and Engineers Club of New York and the Cosmos Club, Washington, D. C.

In the electrical field, Mr. Stillwell has taken out numerous patents, the more important of these relating to the regulation of potential in distribution systems, the original broad patents covering conductive regulation having been issued to him in 1888, the localization of interruptions of service in systems of distribution by means of time limit circuit breakers and the control of systems of distribution by means of pilot switchboards.

Mr. Stillwell has contributed numerous papers to the proceedings of the various societies with which he is connected and to periodicals. Among the most important of these are "Electric Transmission of Power from Niagara Falls," Proceedings A. I. E. E., August, 1901; "Electrical Power-Generating Stations and Transmission," International Engineering Congress, 1904; "Electric Power Generation at Niagara," Cassier's Magazine, 1905; "On the Substitution of the Electric Motor for the Steam Locomotive," Proceedings A. I. E. E., 1907, and "Notes on Electric Towage of Canal Boats," Proceedings A. I. E. E., March, 1908. In the preparation of the two papers last named, his associate, Mr. H. St. Clair Putnam, collaborated.

In 1892 Mr. Stillwell was married to Mary Elizabeth Thurston, of Pittsburg. They have one son and reside at Lakewood, N. J.



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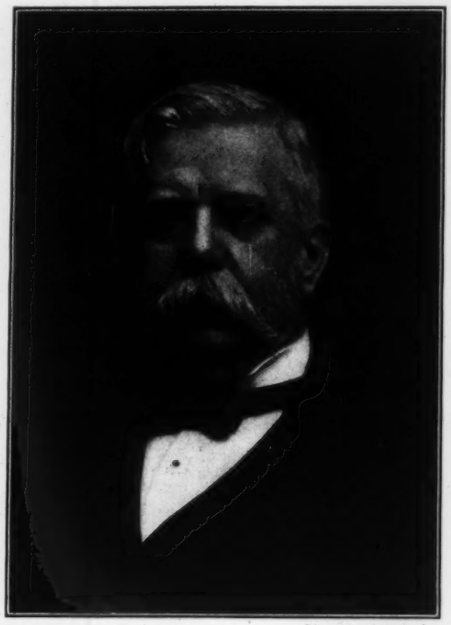

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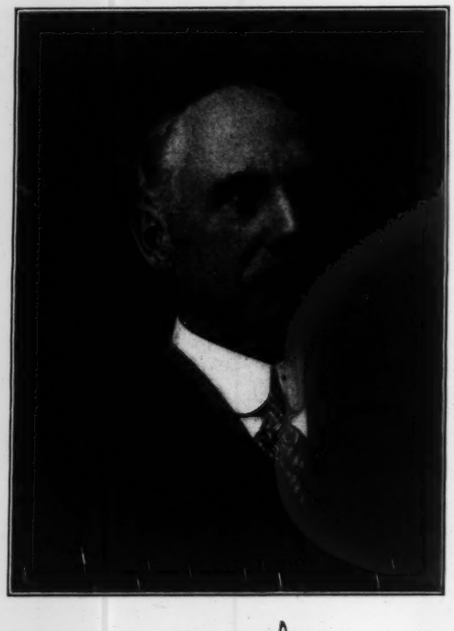

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Those who believe in a great revival of river transportation and look forward to the wholesale construction of piers, wharves and water-front warehouses on the banks of the Ohio and upper Mississippi rivers to make such transportation possible, will do well to seriously consider the effect of ice action on water front structures. Newspaper dispatches from Evansville, Ind., on January 11, estimated the damage due to the movement of ice gorges in the lower Ohio River at over half a million dollars. Making all allowance for newspaper exaggeration, it is yet entirely clear that any engineer planning structures on the banks of a river subject to such floods and ice as the Ohio should take ice action into consideration. That proper terminal facilities are essential to economic transportation is recognized by all who have given careful study to the problem, and the question what such terminal facilities will cost is an important element to be settled in arriving at the total cost of transportation by water.

A case of remarkably rapid deterioration of steelwork under the corrosive action of locomotive gases and smoke is reported in the case of the McCallie ave. bridge at Chattanooga, Tenn., on another page of this issue. Here is a steel truss bridge built in the Spring of 1905 of two 120-ft. spans, with steel floor beams and girders and a timber plank floor, with a minimum clearance of 20 ft. above heavily traveled switching tracks. In the short time it has been in service the reduction in section of the unprotected stringers, floor beams and lower chords has become so great that, within the past month, the city has been compelled to condemn the bridge as unsafe and to close it to all travel.

The report by the City Engineer gives some idea of the extent to which the destructive action has been going on. The fascia 7-in. channel stringer under the cantilevered sidewalk has so little of its 0.21-in. web left that the loss of thickness is recorded as 100%. A 7-in. interior I-beam parallel to the above stringer has suffered a 68% loss in the web and a 43% loss in the flanges; the 24-in. built-up floor beams have lost 57% of their web section and 28% of the flange area and finally the bottom tension chord has a loss of 27% in its available section. This is all in the space of 4½ years, on unprotected steel work at a minimum distance of about 6 ft. from the highest locomotive stack. Nine tracks pass under the two spans and extensive switch yards lie immediately on either side of the bridge, so that switching is constant and the steelwork is exposed to the smoke and gases to a greater extent than would be a bridge over an ordinary trunk line railway.

This is but another example, of magnified intensity perhaps, of the absolute necessity of preventing the continual access of locomotive gases to the steelwork of bridges. Indeed this necessity is so generally acknowledged that it would seem hardly worth while to emphasize it here were it not for the fact that the very bridge in question was allowed to go unprotected until nearly all destroyed, proof that the seriousness of the matter was not recognized, or at least acknowledged, by those in charge of its maintenance. As pointed out some months ago in these columns the encasement of the lower portions of a bridge in concrete has been reduced to an economical possibility for new construction, even considering first cost as the main criterion, and the ease with which some non-corrosive material, such as wood, asbestos-board, etc., may be interposed between the floor system and the track, makes the protection of existing structures a simple procedure. At any event naked steel, or even painted steel, within the range of the locomotive blasts is a poor investment.

The steady decline of typhoid fever in Philadelphia which has accompanied the gradual extension of a filtered-water supply throughout the city is notable. Beginning with 1906, the yearly typhoid death rate per 100,000 is reported as having been 72.3, 58, 35.5 and 21.1. The last-named figure, for 1909, is subject to slight correction. As every one knows, Philadelphia was long a byword to the country on account of its very high death rate from typhoid fever, which at times has gone far beyond the highest of the figures just given. It appears from the records of the Health Department that the improved water-supply has also contributed to the lowering of the general death rate, but, unfortunately, it is difficult to establish such an assumption by positive proof. The reduction in typhoid alone, however, is sufficient justification for the introduction of filtered water.

Considerable commotion was created in Philadelphia some months ago by the circulation of an immense number of broadsides, the burden of which was that the Philadelphia water-works were being run at a great financial loss. These broadsides were a part of the revival of an old scheme for turning over the Philadelphia water-works to private management. In commenting on the subject at the time* we stated that although it was entirely unlikely that the broadsides would accomplish their primary purpose, yet they might very well serve to cause an investigation of charges that the water-works were being run at a loss. However much or little the broadsides have had to do with it, a resolution has recently been adopted in the Philadelphia city councils, without a dissenting vote, authorizing the finance committee to investigate the management of the Water Bureau.

The resolution states that in view of radical changes in the water service during the past ten years there has been a large increase in the cost of maintaining and operating the works, and that this increased cost, together with the expense of further improvements in progress or projected, "indicate that the future cost will exceed the revenues" of the Department. Accordingly the finance committee was directed to "make an immediate and thorough investigation of the management of the Bureau of Water" and report the results of its investigation early in March.

We take it that the Philadelphia councils have at last become impressed with the need for making some adjustment in the management of the water-works department. The heavy expenditures for filtration and improvement of the water supply, which already approach $30,000,000, combined with the enormous consumption and waste, and the heavy cost of pumping, certainly entail a very considerable burden upon the people of Philadelphia. The matter of waste alone and all that it implies in the way of needed heavy expenditures if it is not checked would be sufficient justification for an overhauling of the affairs of the department.

Some years ago when three eminent outside engineers reported on water filtration plans for Philadelphia, it was made apparent that there was urgent need for cutting down water waste, and that if this should be done promptly and effectively the cost of the proposed water purification works might be very materially cut. The authorities of that day preferred to build filtration works of sufficient capacity to provide for the enormous consumption and waste, leaving to future municipal authorities the problem of coping with the problems which that waste was sure to entail. A few months ago it was reported that portions of the city could no longer be given the benefit of a fully purified water-supply, and it was rumored that this was in large part due to the fact that the water consumption and waste had already overtaken the capacity of the filtration plant and pumping works for that section of the city. If this be true, it can readily be understood why an investigation of the affairs of the Water Department should have been ordered. We trust that it will be thorough, and that the city authorities of Philadelphia will have the courage to act in accordance with the disclosures that will certainly be made if the whole aim of the investigation is to show the truth, and if the investigation is conducted with the aid of able and disinterested engineers.

The character of the Trenton water-supply, combined with the continued high typhoid rate of that city, has led the State Board of Health of New Jersey to notify the city authorities of Trenton to appear before the Board and show cause why the city should not be enjoined from continuing to use water from the Delaware River unless it is subjected to purification. It has been a growing practice of late for state authorities to take steps to compel cities to purify sewage; but this Trenton incident is the first case, so far as we now remember, where a city has been summoned to show cause why it should not be required to purify its water-supply. We have maintained for some time past that there was more justification for orders aimed at water purification than for those directed toward sewage treatment. We are glad to note the action of the State Board of Health in the Trenton case. The need for purer water at Trenton has been perfectly evident (to outsiders, at least) for a number of years past. The subject has been considered by the city authorities, we believe, but for some reason they have dallied with the question, instead of taking prompt and definite action to ensure a purer water-supply for the state capital.

The annual typhoid outbreak at Montreal, noted in these columns Jan. 13, seems to have become a little less serious. But that is no reason why the city authorities should not use every effort to settle beyond doubt whether or not the water-supply is the probable source of infection. It seems to be assumed by Superintendent Janin that all that is necessary in the way of water-supply improvement for some years to come is to extend the intake considerably farther into the St. Lawrence River. The assumption ought to be proved or disproved. It appears that studies to that end have been in progress for the past year or two, and that the local authorities

*Aug. 12, 1909, in an editorial tail note to a letter from Mr. John C. Trautwine, formerly Chief of the Philadelphia Bureau of Water. The letter showed some astounding increases in the cost of operating the Philadelphia water-works.

will continue to take samples of water from the present intake and from the end of the proposed extension. Expert advice would seem to be in order.

So far as we can judge from the discussion in the Montreal papers, it does not appear that the authorities of that city have taken up the typhoid and water-supply questions in a way that might be expected at the present day. There are still many local questionings as to whether the water-supply furnished by the city is at all responsible for these annual typhoid outbreaks. A complication arises through the fact that portions of the city are supplied by a private company. It is alleged that typhoid is most prevalent in the company-supplied wards. There is no excuse for ignorance on this subject. Does not the city have records showing the distribution of typhoid cases and deaths by districts? If not, it is high time that it should.

What promises to be a highly interesting development in connection with the present typhoid outbreak at Montreal is a proposition that has been made for disinfecting the water at the pumping station. From the imperfect reports received, we infer that the proposition is to use bleaching-powder or hypochlorite of lime for this purpose, as has been done for some time past at the Boonton reservoir of the Jersey City water-supply.

The reservoir system for river regulation is again brought forward in this issue in a contribution by Mr. C. W. Durham, who canvasses the possibilities of reservoirs for supplementing the low water flow of the upper Mississippi and its tributaries. According to Mr. Durham's computations, it would be possible to store enough water on the headwaters of the upper Mississippi, in Minnesota, Wisconsin and Iowa to very considerably increase the depth and volume of flow in the upper Mississippi throughout the low water season.

Mr. Durham leaves untouched, however, the cost of constructing and maintaining such a great reservoir system; and the practicability of the whole proposition turns on this. It needs only a glance at Mr. Durham's figures to perceive that the vast amount of water which he plans to store will cover an enormous area of land. The cost of this land alone will mount up to a huge sum, and besides this there will be the cost of constructing the dams and their appurtenances. The question arises, therefore, whether the game will be worth the candle. Will the saving in the cost of water transportation on a 12 ft. depth instead of a 6 ft. depth through the four or five months of low water be sufficiently great to pay the cost of all these reservoirs and the land which they flood? The probabilities are that if the cost of the reservoir system were figured in as part of the cost of water transportation the water route would be found to be too costly by far to compete with the railway.

The revival of water transportation is diligently promoted by the advocates of conservation; but with the increasing scarcity of agricultural land, is it not of greater public benefit to preserve the fertile valley lands at the headwaters of the streams than to destroy them for the sake of adding a few feet to the depth of navigable rivers? It is a fair question whether conservation of productive lands is not more important than conservation of water for use in transportation.

One by one the larger cities of the United States which had previously been dependent upon private companies for their water-supply changed to municipal ownership, until among the cities of the first rank San Francisco alone was supplied by a private company. For thirty years past, more or less serious efforts have been made in San Francisco to effect a change to municipal ownership. On Jan. 14, 1910, a popular election was held on two propositions, either one of which alone was expected to prepare the way for an immediate realization of municipal ownership. The first of these propositions involved the issuance of $45,000,000 of bonds for the development of a water-supply from the Tuolumne River in the high Sierras, for supply conduits from the mountain storage reservoirs to the city, and for a distribution system. This proposition was so stated that in case proposition No. 2 carried, the bond issue would be cut to $23,000,000, inasmuch as a distribution system would then not be needed. The second proposition voted upon was for $35,000,000 of bonds to buy the works of the Spring Valley Water Co., which now supplies the city. It appears from press despatches that the first proposition, popularly known as the Hetch-Hetchy project, carried by a very large majority (32,876 to 1,607), but that the second proposition for buying out the water company was lost by 1,234 votes.

In discussing these proposed bond issues on Dec. 16, 1909, we gave reasons why it seemed highly desirable that both propositions be carried. The main reasons were that if the city voted to buy out the company, as well as bring in the additional supply from the Tuolumne River, an apparently needless duplication of the distribution system would be avoided, and that the long controversy between the city and the Spring Valley Water Co. would be brought to an end. With the adverse vote on the proposition to buy the works of the Spring Valley Water Co., it may be expected that that corporation will continue its opposition to the introduction of water from the Tuolumne River. How successful that opposition can be made remains to be seen.

There appeared to be but little objection to the purchase of the works of the Spring Valley Water Co. until within two weeks or so of the election. About that time Mayor-elect McCarthy, who was about to take office, came out strongly against the purchase, alleging that the price proposed was altogether too high, and that the bonds called for by both propositions would carry the city indebtedness beyond the debt limit and therefore defeat the so-called Hetch-Hetchy project, thus leaving the Spring Valley Water Co. in control of the field. The purchase price proposed was a few million dollars in excess of what has been maintained by the city in recent water-rate litigation as the value of the plant, but the city administration which went out of office the first of the year felt that the long-continued controversy might better be brought to a close, even though something extra was paid for the works. The further progress of San Francisco's effort to place itself in line with other large cities of the world by owning its water-supply will be watched with much interest.

One would suppose, after the coal famine from which many cities and towns in the Northwest suffered three winters ago, that due precautions would be taken to store a goodly supply of coal before the advent of winter weather and storms which interrupt railway traffic and regular supplies of fuel. It appears, however, that in numerous quarters in the Central West a coal famine is impending. The railways are straining every nerve to bring in fuel supplies, even canceling passenger service for days at a time and sidetracking all other freight in order to bring in train-loads of coal to shivering communities. The city of Chicago itself has been suffering from coal shortage.

In the current discussions of transportation, the popular prescription offered whenever a railway blockade occurs is that more facilities for water transportation must be provided. It is well to reflect, therefore, that the shivering cities and towns in the West would be not one whit better off at the present time if a network of waterways terminated at their doors. The severe winter weather of northern Illinois and Wisconsin ties up all navigation on inland rivers and canals in November. A community which relied on water transportation alone for its fuel would have to lay in a stock of coal in the summer and fall sufficient to last through the whole winter.

The real cause of the coal shortage in the West is that the public places too great reliance on the regular service which the railways render, and lives too much from hand to mouth. The cost of storing large quantities of bituminous coal and the deterioration which takes place in such storage make consumers prefer to buy in small quantities and rely on the railways' regularity in delivering it to them. It requires some such object-lesson as the present stringency to impress upon coal buyers and coal users the need of providing some storage to carry over possible seasons of railway blockade.

A memorial water-supply system presented to a town in Indiana, is described in the report of the Indiana Engineering Society meeting elsewhere in this issue. Such a monument is surely a most commendable form of public benefaction. It may not appeal to the eye like a library building, a church, a hospital or a public park; but the community receiving such a gift could not fail to hold the donor in grateful remembrance.

Three Kinds of Conservation.

It may be difficult for some readers to understand why the movement to promote the conservation of natural resources, launched so auspiciously at the White House conference of May, 1908, should have become one of the most bitterly contested issues of present-day politics. The special Conservation Message of President Taft, sent to Congress on Jan. 14, makes the present an opportune time to discuss this subject.

Conservation is defined by the dictionary as the preservation from waste, misuse and destruction. All intelligent men who have given attention to the subject agree that waste, misuse and destruction of our natural resources is a crime against posterity.

It is too evident to need proof, that waste or wasteful use of natural resources must inevitably result in serious loss to the world.

Some who have given little attention to the subject say lightly that the period of exhaustion or of scarcity is too far ahead to be worth any serious consideration at the present day. Closer study of the facts, however, shows that the world is already feeling the effect of a reduced supply of natural resources in many branches of industry. In fact, the increased cost of living, concerning which so much is being said nowadays, is traceable in the last analysis to the fact that the production from the world's fields and farms and forests and mines has not kept pace with the increase of population.

All thinking men, therefore, will agree that the gifts of Nature should be used with due care for their preservation, and with all reasonable precautions to prevent waste. When, however, we begin to discuss methods by which conservation of Nature's gifts may be secured, differences of opinion at once arise.

Those who have been foremost in the conservation movement, of whom Mr. Gifford Pinchot is the leader, insist that the gifts of Nature still in state or national ownership shall be held for the public benefit primarily and only transferred to private ownership under conditions which will protect the public against monopoly and will preserve the "unearned increment" (the growth in value certain to take place as the years go on) for the public benefit.

But such a policy comes into direct conflict with a great variety of business schemes. A great many people are in favor of conservation, but they want to do the conserving! The very fact that natural resources are being rapidly used up, makes the opportunity for securing wealth all the greater for those who can succeed in securing ownership of scarce and valuable resources. It is to be remembered, also, that for centuries past all the natural wealth of this virgin continent has been open for appropriation. The policy of nation and states has been to give away at a nominal price, lands, forests, minerals and water power to the first one who chose to take it. The laws have been framed with the idea of giving a small piece of Uncle Sam's vast farm to any man who would settle upon it. The only restrictions have been made with a view of hindering the consolidation of ownership; and these restrictions have been

often more honored in the breach than the observance.

It is far from strange, therefore, that there should be angry protest from those who base their schemes for gaining wealth upon the acquisition of valuable minerals or lands or water power rights still in Government possession.

The interests which thus range themselves against conservation are wealthy and influential. Of course they do not openly oppose conservation. Instead, they urge that these gifts of Nature belong in equity to the States and not to the nation. They deride conservation as a scheme by which the East seeks to tax the West by claiming a share in the value of the West's lands and minerals and waters.

It is this aspect of conservation which has led to a battle-royal in Washington of the opposing elements in Congress, a conflict which has attracted more attention than any other issue of the present session.

The question that confronts the practical statesman is: how to reconcile these diametrically opposing forces. On the one hand, the conservation advocates must be brought to realize that a transfer from public to private ownership for nearly all natural resources is essential before these resources can be converted to public use. On the other hand, those who seek to exploit the coal lands, forests and water-power sites must be brought to recognize the changed state of public opinion and the necessity for guarding the public rights while giving due incentive to private enterprise. There is not the slightest doubt that President Taft is correct in stating that the present laws for the disposal of public lands and their appurtenances are wholly unsuited to present conditions. The theory of the present laws is that the land shall be disposed of in small parcels, and that the takers shall retain them in their possession and not part with them for a limited period of time. The law distinctly opposes the plan by which a number of men may each take up a certain area of coal lands, for example, with the view of later disposing of them to one concern. This is, of course, an absurdity under present-day conditions. It is well recognized that for economic development and operation of mineral property, large ownership and operations on a large scale are essential. Instead of attempting to ensure the dividing up of mineral lands into small tracts, the Government should place its emphasis upon the value contained, and seek to secure the greatest return from the exploitation of the property, regardless of the way in which it is held. From this point of view, it should be clear that the President's recommendation for a radical revision of existing land laws is highly commendable, and that this, in fact, must be done before the natural resources, particularly in the way of minerals, can be developed with a view to the best interests of the people as a whole.

Much more might be said on this aspect of conservation, but we must turn to the third aspect, which may be described as the development of natural resources by public expenditure. To us it seems regrettable that such matters as the improvement of rivers for navigation, the drainage of swamp lands, and the reclamation of arid lands, have become identified in the public mind with the conservation movement. All these works should be considered on their own merits, and it should be clearly understood that unwise and unproductive investment in any of these fields may act for the destruction instead of the conservation of national wealth and national prosperity.

We say this without in any way intending to criticize the President's message, which is commendably conservative in dealing with these matters, particularly with the improvement of waterways. Mr. Taft's statement is well worth quoting, that

> no enterprise for navigation improvement ought to be undertaken, the cost of which is not definitely ascertained and the benefit and advantage of which are not known and assured by competent engineers and other authority.

Another remark well worth the serious attention of the intoxicated waterway advocates is as follows:

> I am informed that the investigation by the Waterways Commission in Europe shows that the existence of a waterway by no means assures traffic, unless there is traffic adapted to water carriage at cheap rates at one end or the other of the stream.

Concerning the Reclamation Service, the President says:

> It would appear that over thirty projects have been undertaken, and that a few of these are likely to be unsuccessful because of lack of water or for other reasons, but generally the work which has been done has been well done.

He thinks that too many projects have been set on foot, in view of the funds available under the Reclamation Statute, and that the projects cannot be completed within a reasonable time. It is on this ground that he repeats Secretary Ballinger's recommendation that authority be given for the issuance of bonds to the amount of not more than $30,000,000.

That the present Reclamation fund might profitably be augmented by a bond issue, we have every reason to believe, provided the work is to be handled in the future on sound principles of engineering and public service. But the ground for the implied criticisms by the President of the past conduct of the Reclamation Service are not clear. It is very likely true that if the Reclamation Law had left the Government free to choose the most advantageous sites for Reclamation, better selections could have been made and the work could have been concentrated on fewer projects. The law, however, stipulated that works should be carried out in each arid state in approximate proportion to the revenues from sales of public lands in that state. This has compelled the taking up of a larger number of projects than might otherwise have been selected.

It is also true that settlers have in some cases rushed in in advance of the completion of the Reclamation Works and taken chances on the works being completed in time for their needs. A bond issue would benefit such settlers who may indeed be in a desperate condition; but it is not fair to blame the past administration of the Reclamation Service for failure to supply these settlers as they were given official warnings that the completion of the project might be long delayed, and made their settlement in disregard of these warnings.

The Boston Experiment in Municipal Government.

For many weeks past Boston has been a center of interest for the thousands of people scattered over the country who are deeply concerned in the improvement of city government. During the same period Boston itself has been in a state of municipal ferment scarcely exceeded in the political history of the city. The occasion for all this has been the first election in accordance with important charter amendments enacted by the legislature of 1909. These amendments were based, in part, on the recommendations of the Boston Finance Commission, a temporary investigating committee which overhauled the city administration of Boston in 1908, revealed gross inefficiency and waste in many branches of the city government and advised radical changes in the charter to aid in securing better administration in the future. The charter amendments proposed by the Finance Commission were reviewed in our issue of March 25, 1909, and were discussed editorially in the same issue. The amendments as laid before the voters were reviewed in our issue of July 15, 1909. Some of the amendments went into effect regardless of the will of the people; others were submitted to popular vote in the form of alternative propositions involving (1) some of the radical changes advised by the Finance Commission, including nomination by petition, abolition of party designations on ballots, modified recall for the mayor after two years of a four-year term, and a city council of nine members, elected at large; as opposed to (2), the old party system of nominations and elections, a two-year term and no recall for the mayor, and a council of 36 members, 27 elected by wards and 9 at large (see diagram illustrating differences between the two plans, p. 353, Sept. 30, 1909). The first of these plans carried, as we reported with editorial comment in our issue of Nov. 11, 1909.

The first test of the Boston charter amendments came on Jan. 11, when an election was held to choose a mayor and city council. The result that has been given chief attention outside of Boston was the election of the very man for mayor whose previous administration of that office had led to severe condemnation by the Finance Commission. This has been interpreted by many as proof that the new plan of government is to be a failure from the start, but it proves nothing of the kind. The real test will be the effect of numerous important provisions of the charter amendments upon just such a man as has been elected to office—be he as bad as he has been painted by the Finance Commission, the Boston daily press and the reform element generally, or be he as devoted to the best interests of the city and its people as he claims and as almost half the voting electorate appears to believe. Moreover, the very election machinery that put John F. Fitzgerald back in the mayor's chair (that is, nomination by petition, abolition of primaries and conventions and absence of party designations on ballots) has resulted in choosing a council composed of 7 so-called reform candidates out of a total of 9 members.

As a matter of interest and for the sake of record the votes received for each of the four mayoralty candidates may be given: John J. Fitzgerald, 47,172; James A. Storrow, 45,757; Geo. A. Hibbard, 1,816; Nathaniel H. Taylor, 613. This makes a total of 95,358 votes cast for mayor out of a total registration of 112,671. Fitzgerald had a plurality of 1,415 votes, but he lacked 1,014 votes of a clear majority over all rivals.

One of the chief arguments advanced against nomination by petition was that it opened the race to all comers and made it possible for a candidate to be selected by a small minority of the voters. Although four candidates ran for mayor there were only 19 men put in nomination to fill the 9 councilmanic positions and only two candidates (a man and a woman) for the one school committeeship. Moreover, when it came to voting for mayor only 2,500 out of 95,000 voters paid any attention to Hibbard and Taylor, notwithstanding the fact that Hibbard was running for reelection and had beaten Fitzgerald two years before.*

In the election last week the two real rival candidates were both of the same national party, while Hibbard was of the opposition party. The voting was largely on men, rather on parties, although presumably most of Fitzgerald's votes came from his associates in national politics, while most of Storrow's votes came from the opposition.

All things considered, the mayoralty results can hardly be regarded as an argument against nomination by petition. Rather they may be considered as strengthening the argument for accompanying nomination by petition with a requirement for a majority instead of a plurality vote to constitute an election, with a second election to effect a choice between the two highest candidates whenever a clear majority is lacking. This is the new practice at Berkeley, Cal., as noted in our issue of March 25, 1909.

We have already noted that a majority of the new council at Boston will be in opposition to the mayor elect. Since the council was elected at large instead of by districts the nine men having the highest number of votes were the successful candidates. Their votes ran from 47,149, or substantially the same as the number given the mayor-elect, to 36,279. The five highest men on the list, together with the seventh and eighth, were classed as reform candidates. The three highest serve for three years, the next three for two years, and the lowest three for one year each, which gives a still further advantage to the so-called reform element. Moreover, of the ten defeated candidates, with votes

*In the 1907 election, it may be added, Hibbard received 38,112 votes; Fitzgerald, 35,935; and an "independent" candidate 15,811. Thus Hibbard had a plurality of 2,177 and led Fitzgerald by 12,177 votes. The total vote in 1907 was 89,871, out of a registration of 111,430.

ranging from 36,136 to 28,560 each, the highest was endorsed by both the Citizens Municipal League and the Good Government Association. This seems to show intelligent independent voting.

We call particular attention to the fact that in this election there were only eleven offices to be filled, and that hereafter, with only three councilmen to be elected yearly, there will never be more than six vacancies at one election, while in years when there is no mayor and only one school committee member to be chosen (the school committee consists of five members) there will be only four offices to be filled. The short ballot, as this plan of very few elective officers is called, makes it possible for voters to inform themselves of the merits and demerits of each candidate and to vote with a degree of discrimination that is quite out of the question when there is a mayor, scores of councilmen, numerous members of a board of education, a city attorney, city treasurer and many other officers to be voted on.

Nor does the benefit of the short ballot stop with the election. The voters can pass intelligent judgment on the official acts of such of the candidates as are elected, and the latter being few in number it is comparatively easy to place responsibility upon them and to deal with them according to their deserts when the next election day comes round. Obviously, the fewer elective officers the larger the number of appointive officers, and the greater the chance that able and efficient men will be chosen for administrative positions. When the mayor has supreme power of appointment and removal, as will be the case hereafter in Boston, responsibility for the choice of all administrative officers other than the mayor rests with one man and his administration will be judged by the success or failure of his appointees.

This brings us to the situation that confronts the mayor-elect of Boston and the people of that city to-day. Almost 50% of those who voted on Jan. 11, and about 42% of the registered voters, declared for the return to office of a man who for months past had been subjected to the most sweeping adverse criticism ever bestowed on the administration of an ex-mayor. When he takes office again in February he will find himself possessed of far greater powers than he had during his previous administration, but with many of his great responsibilities no longer divided between himself and the city council. Moreover, he will be subject to limitations on appointments and to investigations of his actions, both by State officials, never placed on American mayor before.

As to appointments, the mayor is required by law to make his choice "without regard to party affiliation or to residence at the time of appointment." He must sign one of two forms of certificates for each appointee. One form certifies that in the opinion of the mayor the appointee "is a recognized expert in the work which will devolve upon him;" the other states "that in my opinion he is a person specially fitted by education, training or experience to perform the duties of said office." Either form concludes with the statement that "I make this appointment solely in the interest of the city." The choice between the two forms is to be governed by the facts in the case.

This is not all. The appointment does not become effective until the certificate has been endorsed by a majority of members of the civil service commission (state appointed), to the effect that

they have made a careful inquiry into the qualifications of the appointee, and that in their opinion he is a recognized expert, or that he is qualified by education, training or experience for said office, as the case may be.

As to investigation of the actions of the mayor, a permanent Finance Commission, appointed by the governor of Massachusetts, is charged with the duty of investigating

any and all matters relating to appropriations, loans, expenditures, accounts, and methods of administration affecting the city of Boston and county of Suffolk, or any department thereof, that may appear to the commission to require investigation, and to report thereon from time to time to the mayor, the city council, *the governor or the general court* [state legislature; italics ours.—Ed.]

The commission is authorized to employ "experts, council, and other assistants," at its discretion. Its total expenditures, up to $25,000 a year, plus $5,000 salary for the chairman, must be provided for in the annual city appropriations.

These provisions regarding the certification of appointees and the Finance Commission provide standards and methods of judging the acts of a mayor unique in the history of municipal administration. They alone are sufficient to show that the new plan of government for Boston cannot be judged merely by election results under the nomination-by-petition plan, as so many have assumed.

So far as the election results indicate, we think the charter amendments have been salutary. The main test of the amendments will be their effect upon the actual administration of the city hereafter. We cannot see how the net result can be other than highly beneficial. The increased and clearly defined powers of the mayor, combined with the small council of only nine members, curtailed of all semblance of executive powers, seems to meet as never before the demand for a complete separation of executive and legislative functions which has been growing in popular recognition and favor ever since it was clearly outlined by the National Municipal League, ten or a dozen years ago. At the same time many of the advantages of the so-called commission plan are secured.

Members of the engineering and other professions which require technical knowledge and experience can scarcely fail to watch the Boston experiment with interest, since it makes professional reputation or else "education, training or experience" requisites for all appointees to heads of departments. The interest will not be confined to Boston, both because the workings of plan will be instructive to other communities and because residence will no longer be a condition of appointment to technical administrative positions in the Boston city government.

LETTERS TO THE EDITOR.

Concrete Laying on the Gatun Locks in December.

Sir: The following statement of concrete placed in the Gatun Locks during the month of December may be of interest to the readers of Engineering News as a probable high record to date in concrete output from a single mixing plant:

Total days worked.....	26 (12 hours per day)
Amount placed	43,100 cu. yds.
Average per day.....	1,658 cu. yds.
Maximum in one day.....	1,786 cu. yds.

The rainfall at Gatun during the month of December amounted to 31.48 ins., which is, with one or two exceptions, the greatest ever reported at this place. It is expected that the above monthly output will be materially increased during the dry season.

Yours truly,
Geo. M. Wells, Office Engineer.

Gatun, Canal Zone, Jan. 7, 1910.

The Use and Abuse of Cost Data. Cost Records on the Isthmian Canal Work.

Sir: While thoroughly agreeing with your editorial comment on the use and abuse of cost data in Engineering News of Dec. 23, it seems to me that your criticism of the insufficient basis on which certain adverse statements about the Isthmian Canal work have been made, applies with the same force to various published eulogies of that work.

It may be that the Isthmian Canal Commission is now in a position to manufacture its castings for repair work more economically than they can be bought in the open market, but a more detailed discussion would seem necessary to prove it than the figures quoted in your editorial of Nov. 25, 1909, from the latest Annual Report of the Commission. Remembering previous charges by the Isthmian shops for castings made for the Municipal Engineering Division while I was Resident Engineer at Panama, where we had manhole covers billed against us at four times the market price in New York, your deduction from these figures (the accuracy of which I do not question) that they are typical of all such work, is rather a broad generalization from a very small cost item.

Having been for over five years connected with various portions of work on the Isthmian Canal, including three years in charge of Panama City municipal improvements, I heartily endorse your appeal to the engineering profession for a better appreciation of the work that is being done, and that has been done, by the members of the profession, at Panama. I do not, however, feel, that justice to the Isthmian Canal organization, however much it may be adversely and ignorantly criticised, requires approval of all its work by those who have no prejudices in the matter, nor that there may not be honest critics who, though they may disagree with its methods or plans, are neither "amateur engineers" nor "opposed to any canal."

That there has been much incorrect and not disinterested criticism of the canal work in the past, should not be taken as any cause for closing all debate on the subject in the future.

Very truly yours,
Henry Welles Durham.

Sandwich, Mass., Jan. 14, 1910.

[The figures of foundry costs quoted in our editorial of Nov. 25, 1909, were not taken from the Commission's annual report but were obtained personally on the Isthmus by a member of our editorial staff. We have at no time taken the position that the Panama work was above criticism; but we have condemned the "half-baked" criticism based on partial knowledge which has been rife in the newspaper press and has even been circulated in engineering circles.—Ed.]

More Concerning the Reclamation Service and Others.

Sir: No thoughtful person can read your last week's editorial on the Reclamation Service without recognizing what he may perhaps have felt many a time and oft before:—that the U. S. Government, also the Governments of the States of our Union, are at a great disadvantage in the carrying out of public works, by reason of having no permanent body of civil engineers in their employ.

It seems to have been the idea of the founders of the Republic that the construction, maintenance and operation of what ordinarily are called public works, was without the scope and province of a republican form of government. Indeed, a study of U. S. history will show that 90 or 100 years ago the "strict constructionists" openly held that view; when, instead, it is now plain to most of us, that the construction and conduct of public works should have been provided for in the organization of government, fully as much as, say, Boards of Health, if not as, say, the rest of the Executive, or the Judiciary. For no state ever did, or ever will flourish without public works.

It was the lack of such an organization for the conduct of public works, when brought face to face with the dire necessity of having them, that first led in the United States to the detail of Army officers to do the work of civilians in that line; a unique, perhaps almost absurd feature of our governmental policy, the like of which is not to be found elsewhere the world over, unless it be in the similar incongruity of Army officers doing in England the work done in this country by the Interstate Commerce Commission and the several Boards of Railroad or Public Service Commissioners.

That army officers have been able to accomplish anything at all in the false position in which they have thus been placed, is due largely to the fact that they hold life positions under the Government. This makes for honesty in the service; for other forms of faithfulness of service; for ability to serve, in the cases of work extending through long series of years. Without it, as you have pointed out, an *esprit de corps* becomes impossible to build up; men resign; the work sickens and dies.

This sort of mildew and decay is helped, moreover, by the fact that the supreme command is in the hands of laymen. In fact, this last must be counterbalanced by life positions of the subordinates, to get any results in public works worthy of the name.

Said the President of the Institution of Civil Engineers of London, in his last year's inaugural address:

> Another, and somewhat consoling consideration, I would venture to place before you, and then I have done. The ideals of nations are different as we all know, but I was hardly prepared for so precise a statement on the British and German ideals, as that made recently by an eminent German professor lecturing on economic subjects. He said:
>
> "The aim of the German was everywhere to leave as little as possible to chance in the great struggle of the twentieth century; not to allow people to muddle through somehow, but to eliminate as far as possible the element of the unforeseen, while carefully training the mind to cope, if necessary, in an intelligent way with any emergency.
>
> "While the British had, as a rule, a violent suspicion of the expert, and a strong belief in the untrained, unpaid amateur as the right source of wisdom, allowing the expert to advise and the amateur to decide, the German had no fear of the expert. He well saw the possible danger of red tapeism at the hands of the highly trained official, but he found them less than the dangers arising from decisions of well meaning, but untrained and inexperienced amateurs."

You have well said that the work of the Reclamation Service has been the pride of the Civil Engineers of the country. Only by giving members of this service the

same permanent positions held by the Army, the Navy, the Coast Survey, the Revenue Service and many more, can we expect eventually to have the Civil Engineering required to be done by the United States, well done by Civil Engineers. Only then can the work survive assaults liable to be made upon its conduct at any time, by some exalted being, who, though he only "strut his brief hour on the stage," is yet capable of leaving wrack and ruin behind him. No matter even that he act from motives which to him seem wholly good. He may be mistaken; and certain it is, that the system that enables him thus to radically disorganize, out of his own mere motion, is not for the good of the sevice, nor of the body politic. C. H.

2 Wall St., Jan. 17, 1910.

Hauling a Steam Shovel by Gasoline Traction Engines.

Sir: You may be interested in the following statement regarding the use of traction engines on the construction of the Los Angeles Aqueduct. It is necessary to do a great deal of hauling on the desert and mountain roads and, for this purpose, traction engines of the caterpillar type have been used with satisfactory results, particularly in the moving of heavy equipment and machinery.

On the Mojave Division, we have just moved a No. 40 Marion steam shovel by traction engines a distance of 31 miles at a very low ton-mile cost. Four engines were used, three on the shovel which weighed 30 tons, and one on the boom, turntable and some minor parts which weighed 10 tons. Two specially made trucks carried the principal load. The "Caterpillars" weigh 8 tons and are driven by 40-HP. gasoline engines which burn petroleum distillate. The following figures include preparatory work, switching and return of engines to camp, a distance of 22 miles.

Total load	40 tons
Distance	31 miles
Total haul	1,240 ton-miles
Total cost	$175
Ton-mile cost	$0.141 per ton-mi.
Total time moving shovel	35½ hours
Actual running time	21 hours

The roads over which the engines traveled were good for about 20 miles of the distance. Eleven miles were sandy and bad for ordinary wagon haul. The maximum adverse grade was 8% for about one-half mile; the remainder was quite flat or down hill.

The special feature of this haul is not alone the low ton-mile cost, but the fact that the efficiency of the equipment and of the crews permitted the handling of a 30-ton load in one piece over soft roads, thereby saving the time and expense of dismantling the steam shovel.

The views show the shovel being hauled over rolling country, two of the engines being in the lead and one in the rear for the purpose of holding back.

Yours truly,

J. H. Robinson,
Division Engineer (Mojave Division).

Los Angeles, Cal., Dec. 13, 1909.

[The type of traction engine mentioned in this letter was described in Engineering News Feb. 18, 1909. The fuel cost of hauling freight on the same division of the aqueduct was then reported as roughly 0.7 ct. per ton-mile, but, of course, this included none of the labor, switching or return charges included in the above record.—Ed.]

A NEW OHIO RIVER BRIDGE is in prospect, the War Department having at length approved the proposal for building a bridge at Parkersburg, W. Va. The structure is to have a main span of 800 ft., a total length of 3,000 ft., and a deck carrying a highway and double-track electric railway. Reports have it that it will be a suspension bridge. It is being promoted by the Parkersburg Bridge Co. The structure will give interurban railway connection between Pittsburg and Ohio points, and between Columbus, Ohio, and Parkersburg and adjacent points in West Virginia.

HAULING A 40-TON STEAM SHOVEL ON THE MOJAVE DESERT BY GASOLINE "CATERPILLAR" ENGINES.

Annual Meeting of the Indiana Engineering Society.

The annual meeting was held at the Denison Hotel, Indianapolis, Ind., on Jan. 13, 14 and 15, with a good attendance, a long program and a large display of exhibits. These last included a number of drawings, etc., representative of the student work in the engineering department of Purdue University. A dinner was held on the first evening, but all the remainder of the time was given over to the reading and discussion of papers, the usual provision for an afternoon excursion being omitted on account of the number of papers to be presented. It may be noted, however, that the proceedings were singularly lacking in discussions of the numerous and varied subjects, many of the papers being allowed to pass almost unnoticed in this respect. The election of officers resulted as follows: President, E. E. Watts, Princeton, Ind.; Vice-President, C. C. Brown, Indianapolis; Secretary and Treasurer, Charles Brossman, Indianapolis.

THE NEW INDIANAPOLIS GAS PLANT.—The illuminating gas and by-product plant recently completed by the Citizens Gas Co., was described by Mr. J. M. Forrest. The franchise for this company (based upon that of the old natural-gas company) set the price at 68 cts. per 1,000 cu. ft., owing partly to the knowledge that most American gas companies are able to earn profits on inflated capitalization at prices from 80 cts. to $1, and partly to the report of two engineers who were detailed to investigate the matter. In deciding upon the process of manufacture the company had a free hand, as it had no old plant and was independent of any manufacturing interests. The ordinary water-gas process was considered too costly in operation, as there are no by-products, although it has the advantage of low first cost. The retort process has an advantage of producing by-products which can reduce the cost of manufacture, while it uses up a portion of the coke produced. But the cost is high in spite of this, especially as the gas requires to be enriched. Two points aimed at in the selection of a process were low cost of production, and a minimum amount of gas-house coke to be marketed. The use of by-product ovens was studied therefore, and it appeared that foundry coke would find a ready market in Indianapolis, although blast-furnace coke would not be profitable as the main product, while the culls from the foundry coke would make a better domestic fuel than the ordinary gas-house coke, being much denser than the latter. The next step was to decide upon the type of oven, and after considering many types the United-Otto oven was adopted, this being an improvement upon the Otto-Hoffman.

The plant occupies a tract of 22 acres. The coal is discharged from cars into a track hopper, and conveyed to a crushing plant which consists of a magnetic separator, breaker, pulverizer and mixing apparatus. It is then conveyed to a 500-ton bin over the ovens, from which it is fed to the charging larry. When the charge is carbonized, it is forced out as a solid block, and pushed into a quenching car which is but a little wider and longer than the block of coke. The coke is then delivered to a set of crushers and screens.

The ovens are 34 ft. long, 7 ft. thick, 16 ins. wide at the pusher end and 18 ins. at the quencher end. There are two batteries of 25 ovens each, with two hydraulic mains between them. The richer portion of the gas, which is for distribution, is taken off by one main and sent to the purifiers. The poorer gas is taken off by the other main and sent to a small fuel gas plant, from which it is returned to the ovens for heating. The storage holder is of 1,000,000 cu. ft. capacity, and the gas is sent to the city through high-duty exhausters. The by-products of the plant are coke, tar and ammonia. The plant is in operation, but much of the outdoor work remains to be finished.

CONCRETE RAFT FOUNDATIONS FOR BUILDINGS.—This paper was by Mr. M. Andrews (of the W. P. Carmichael Co.), and described the raft type of foundation, covering the

entire area of a building, which may be considered as a development of the grillage or spread foundation long used for columns and walls. Its use is limited to sites where the soil is compressible, uneven or unstable. It may be divided into three classes: (1) a flat slab of plain or reinforced concrete, without girders or beams to distribute weight or pressure; (2) beams or girders with a slab on top; (3) beams or girders with a slab underneath, the action of forces being as in an inverted floor.

The steel package plant of the National Lead Co. at Granite City, Ill., is on a swampy site covered with refuse and cinders to raise the grade. It is 72 × 180 ft., two stories high, the roof being designed as a future floor when additional capacity is required. The slab is 14 ins. thick, and upon it are girders 17 ins. wide and 38 ins. high, 16 ft. apart. The cells formed by the girders are filled with slag, to ballast the raft and to deaden the vibration due to the stamping machinery. The load is very heavy: 800 lbs. dead weight of building, 800 lbs. dead load of slag fill, and 400 lbs. live load, or a total of 2,000 lbs. per sq. ft. in all. For this reason, trenches were left in the slab to expose the reinforcement, so that the girder stirrups could be hooked under the rods of the slab. For ordinary loads, however, the slab may be built complete (with short vertical bars or dowels along the lines of the girders to absorb the theoretical shear), and then place the girders independently of the slab.

The Y. M. C. A. Building at Mexico (Mexico) is built on a foundation of light volcanic ash, and the instability of the soil, together with the liability of earthquakes, made the slab foundation an ideal construction. The limit of load for the soil is about 1,000 lbs., but the unit pressure of the foundation is reduced to 800 lbs. per sq. ft. by cantilever portions of the slab extending under the sidewalks and area ways. This reinforced-concrete building (not yet completed) sustained two very heavy earthquake shocks in July, 1909; the second floor being then less than two days old. It rocked as a unit, however, and not a single crack appeared in the green concrete during or after the shocks. Both of these buildings were designed and constructed by the Wm. P. Carmichael Co., of St. Louis.

A foundation of the same type, for one of the buildings of the Corn Products Co. at Argo, Ill., was described and illustrated in our columns Aug. 26, 1909.

Concrete construction was the subject of several papers and reports. Mr. E. E. Watts described three works of unusual character which were designed and built by him last year. The first was the reconstruction of the water-works distributing reservoir at Jasper, Ind. This was formed originally by an earth bank and was lined and paved with brick, but in consequence of leaks and serious cracks it has been rebuilt as a rectangular reinforced-concrete tank about 100 × 125 ft. The inner slope of the old bank was excavated, so that the concrete wall is about in line with the inner edge of the top, but the wall rises above the top of the bank. The wall is of the cantilever type, 17 ft. high, 20 ins. to 8 ins. thick, with the batter on the inside. The footing is 20 ins. thick, and extends 6 ft. inside the reservoir, where it joins the 6-in. floor. The second piece of work was the protection of a highway in Gibson County at a point where the Wabash River was eroding the bank. Parallel retaining walls were built, with a solid slab floor between the footings, and transverse concrete beams as ties near the top of the walls to act as ties, an embankment being formed between the walls, carrying the road on top. The river channel is on one side, but in times of flood there is water on both sides. The third piece of work is a flood lock at the outlet of Hovey's Lake, Indiana, and is a combined lock and highway bridge of 24-ft. span and 19 ft. high from the outer sill. It was originally intended to drain the lake, but a State law forbids the drainage of lakes of over 10 acres. The gates take a top bearing against a buffer under the bridge floor as well as against the sill. The gates, of course, are to prevent flood water in the river from entering the channel which leads to the lake.

The report of the Committee on Concrete consisted practically of three separate papers: (1) "School-house Floor Construction," by D. V. Moore, advocating the use of concrete, and describing such a floor in one of the Indianapolis schools. This has a 2-in. slab, with 4-in. ribs 12 ins. apart, and hollow tile between the ribs. (2) "A Concrete Roof," by A. J. Hammond; this referred to a building at South Bend which has a public hall 62 × 66 ft. with the roof designed to serve as a roof garden. There are three trusses, from which are suspended transverse lines of steel beams 6 ft. apart. The beams and trusses carry a 3½-in monolithic slab, whose edges rest on galvanized strips on the brick side walls. (3) "The Surface Finish of Concrete," by H. C. Brubaker. In the walls of the Tuberculosis Hospital at Rockville, Ind., the concrete was spaded to bring the pebbles against the form (instead of away from it); the forms were taken down when the concrete was 24 hours old, and the surface was brushed with wire brushes before the cement was hard, so as to leave a rough surface with the pebbles exposed.

Mr. O. B. Zimmerman described the design and construction of a plant for the Rumley Co. for the manufacture of oil traction engines intended for agricultural work. The column foundations are pile clusters capped with concrete, the caps of the outer row (17 ft. c. to c.) being connected by concrete arches whose horizontal tops, at the ground level, form the foundations for the walls. The main building is of structural steel, with concrete walls, and having in each of the side bays an upper floor of concrete arches on corrugated-iron centering sprung between the I-beams. A paper on "Arches," by Prof. Malverd A. Howe, illustrated by lantern slides, traced the development from the arches of the ancient Persians and Egyptians to the steel and masonry arches of the present day.

STREAM POLLUTION, WATER PURIFICATION AND SEWAGE PURIFICATION.—Dr. J. N. Hurty, of the Indiana State Board of Health, presented a paper on "The Ohio River Sanitary Commission," with information from the report of W. W. Elliott Kimberley, an engineer appointed to make an examination of the river in regard to its pollution by sewage, garbage, manufacturing wastes, etc. The commission was organized to represent the several states bordering on the Ohio, for the purpose of determining and carrying out some uniform system for the protection of its waters from pollution, as the river is the source of water supply for so many communities. A report has been made to the governor, asking for an appropriation for work by the State Board of Health in this direction. In general the purpose of the commission is similar to that of the Lake Michigan Sanitary Association, composed of representatives of states fronting on the lake and communities drawing their water supplies therefrom; this association was organized on account of the increasing pollution of the lake by sewage and industrial wastes, as has been noted in our columns. Mr. A. H. Horton presented a paper on "The Work of the Water Resources Branch of the U. S. Geological Survey in the Ohio Valley."

The report of the Committee on Stream Pollution referred to the law passed by the last legislature, giving the State Board of Health more power over the protection of streams from pollution, but no appropriation was made to pay for the work under the new law. The most serious pollution in the State is that of the White River at Indianapolis, which has been described at different times, and which reaches an almost incredible condition. A paper by W. H. E. Jordan dealt with "The Character of Stream Pollution as Affecting the Design of Water Purification Plants," and briefly described a number of plants treating waters which have varying kinds and degrees of pollution, turbidity, etc. At some of these plants the use of hypochlorite of lime has made it possible to reduce the amount of coagulant and also produce an effluent of a more uniform character. The conclusions presented were substantially as follows:

Plain slow-sand filtration is adequate for water slightly affected by color, suspended matter and bacterial life; it may be treated also by rapid filtration if preceded by the use of hypochlorite. For water affected by dissolved color, mechanical filtration preceded by the use of sulphate of alumina is most effective. Waters high in bacterial life and organic matter are best treated by settling, roughing filtration, and final slow-sand filtration, rather than by any single treatment. In these cases, it appears that the use of hypochlorite will make it possible for the process to be very much condensed; and it is probable that the final slow-sand filters also may be operated more nearly at the rate of mechanical filters or abandoned entirely. Finally, these waters carrying constant and high amounts of coarse suspended matter are satisfactorily purified by coagulation, sedimentation, and the recent modification of the use of hypochlorite.

A paper by Prof. Sackett outlined the history of sewage purification plants in Indiana, dating back to sewage tanks at the Boy's Reform School, Plainfield, and for a residence district at Indiana Harbor about ten years ago. One of the latest plants is that at Bloomington, while La Porte (12,000 population) is planning a large system of concrete sewers and a purification plant. Mr. Charles Brossman described a suggested sewage disposal plant for Indianapolis. The city has the continued type of sewerage, but the suggested plan provides for storm overflows, so that the disposal plant would receive the dry weather flow and the water from light rains. It includes settling tanks, sprinkling filters and settling basins, and has an assumed capacity of about 20,000,000 gals. of sewage per day. The sewage would have to be pumped for a small lift, and for this a producer gas plant with gas engines and centrifugal pump is provided. The sludge would be delivered to centrifugal separators, and to dryers, after which it would be mixed with coal and elevated to the pockets supplying the producers.

MEMORIAL WATER-WORKS.—One of the interesting papers dealing with water supply described the water-works system and drinking fountains presented to Thornton, Ind., by Gen. Anson Mills. Water is raised from a 110-ft. well by the air-lift system and delivered to an underground concrete reservoir of 20,000 gals. capacity. A turbine centrifugal pump raises it to a steel 40,000-gal. water tower 80 ft. high. All the machinery is operated by electric power. The distribution system serves the entire town, and the waste water from the fountains and the consumers' taps is carried off by a sewer system, also donated by Gen. Mills. There are two handsome fountains, the smaller one being for dogs and horses. Bronze tablets on the larger fountain bear this inscription: "To the memory of James P. Mills and Sarah Kenworthy, by their son, Anson Mills."

The deep well system at South Bend, Ind., was described in a paper by Mr. A. J. Hammond. The wells draw from a bed of coarse gravel, overlaid by a bed or blanket of impervious clay, which prevents contamination from the surface and maintains the pressure. There are 33 wells, 4 to 10 ins. diameter and 110 to 125 ft. deep. Very little system was observed in locating them. With all the wells in use, water has been pumped for short periods at the rate of 9,000,000 gals. per day, but this is about the limit of the present layout. The static head has not been reduced materially (if at all) during the past 15 years, and the prospect of a continuance of a very sufficient supply from this source is so good that the field will be developed by sinking new wells.

ROADS AND PAVEMENTS.—One of the important features in relation to this class of work was the adoption of resolutions advocating the establishment of a non-partisan State Highway Commission as the best means of regulating the construction and maintenance of public roads and distributing the funds for such work. The cost would be apportioned between the state, the township and the abutting property. The commission should also have supervision over plans for local roads. The resolutions set forth that the state has a great mileage of gravel roads, built at the expense of the landowners, but that the roads are being destroyed by the tremendous increase of self-propelled vehicles, while under the present obsolete system of maintenance it is impossible to maintain the roads in

proper condition, although nearly $5,000,000 is spent upon them annually. In addition to this question of repair and maintenance there is a demand for more and better main roads. The last legislature passed a law providing for the appointment of a commission to investigate plans for the utilization of convict labor without causing interference with free labor, and the resolutions noted above included a recommendation for the use of convict labor on the roads.

Other papers included "Tests of Creosoted Paving Blocks," by Prof. W. K. Hatt; "Brick Paving in Center Township, Delaware County," by Mr. J. O. Potter; "Bituminous Road Construction," by Mr. C. A. Kenyon; and "The Pneumatic Street Sweeper," by Mr. B. Smith. In connection with a paper on "Proper Methods of Brick Paving," Mr. W. P. Blair (National Paving Brick Manufacturers Association) showed a number of views of the brick-paved speedway for automobiles at Indianapolis, and of brick paving on the country roads of Cuyahoga County, Ohio.

The matter relating to railways included (1) committee reports on the work and condition of the steam and electric railways in the state; (2) papers on block signaling and the supervision of interlocking plants by the Indiana railway commission, by Prof. H. O. Garman; (3) a paper on "The Requirements of a Maintenance-of-Way Engineer," by Mr. L. O. Lower; and (4) a paper by Prof. Hatt on "Railway Track in Germany," giving the results of observations made during a trip to Europe last year.

A New Design of Steam Pile Driver: Comparisons of Several Types of Drivers.

By A. A. GOUBERT,* M. Am. Soc. M. E.

Steam hammers for pile driving have been used to very considerable extent for many years past, but there have been several objections to any design of such drivers placed on the market up to the present time. For instance, a majority committee report before the Association of Railway Superintendents of Bridges and Buildings, in 1904† favored the steam hammer for all kinds of work; particularly when a bonnet was used on the pile. But when this report was presented, the members of the association in general, criticised the findings, as it was generally believed that for hard driving there was not enough energy in each blow of the hammer. The steam hammer as heretofore designed has been found too long and too heavy to swing easily into position on much of the work. It has been found particularly difficult to use such drivers in cramped positions. Moreover, in much pile driving and trestle-making many improvements in methods of placing the piles, in straightening and bracing and in sawing the tops, were needed before any great reduction in the time of actual driving was necessary. Great fields for the use of steam hammers have been shown to exist where speed of driving is important and where great numbers of piles have to be driven close together.

There is a question as to the permissible limit of velocity with various weights of hammer on gravity-drop drivers. It is obvious that to a large extent it should depend on the resistance offered to the sinking of the pile, but it also seems advisable to limit the velocity of the hammer at the end of its fall to prevent excessive brooming of the top or bulging of the end. According to some authorities, a fall of some 45 ft. should not be exceeded. It is common experience that the same penetration can usually be secured by a large number of much shorter drops as with a few long ones and without destruction of the pile itself.

If the short blows can be made with sufficient rapidity there is also an increase in the efficiency of the driver as the soil does not have time to re-compact itself about the pile, and the resistance to driving is actually lessened. With the gravity drop hammer, the maximum number of blows obtainable, 8 to 12 per minute, is not sufficient to prevent the settling back of the soil. It will be seen at once that any steam driver will have a shorter drop of hammer and that the blows may be given at a much greater speed than with any gravity-drop machine.

There are essentially two distinct types of steam hammers. In the first, the steam, acting under a piston, raises a weight which is allowed to drop by gravity. The piston rod may be attached to the hammer or the cylinder may be the hammer. As the apparatus must be kept within practical sizes, the stroke is limited to from 20 to 30 ins. This being the minimum height of the fall, a heavy drop weight must be used to secure a sufficient force of blow, especially as there is probably a slight retardation of the fall due to back pressure of the steam against the piston during exhaust. With these hammers, a speed of about 60 blows per minute can be obtained. This is an improvement over the speed obtainable with an ordinary drop hammer, but the considerable size of the hammer is a drawback in this type, a 3,000-lb. hammer delivering a blow of 7,500 ft.-lbs., being over 12 ft. high, and requiring, for some work, a 75-ft. derrick.

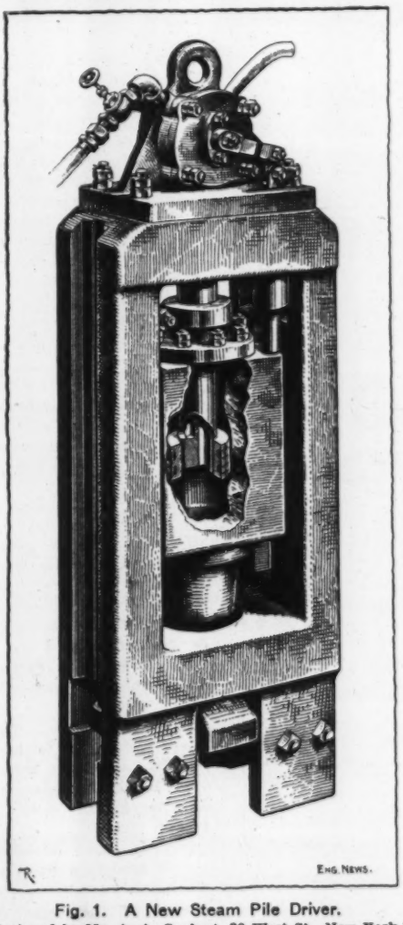

Fig. 1. A New Steam Pile Driver.
(Designed by Mr. A. A. Goubert, 90 West St., New York.)

In the second type of steam hammer, a double-acting steam cylinder is used. In the designs hitherto seen, the piston rod is keyed to the hammer and the piston and hammer drop together. After lifting the weight, the valve is reversed and steam is applied on the top of the piston to propel the hammer downward at a greater speed than would be obtainable from gravity alone. A shorter stroke can be used and a greater number of strokes can be obtained with this type than with that just noted. A hammer of this type can easily deliver 200 blows per minute.

As the work is very severe, especially when driving steel sheet piling, there are heavy percussion effects on the hammer. The weakest part of designs, previously evolved, has been the piston rod. This, being of comparatively small area and attached to the hammer, is often stressed beyond its elastic limit. Repeated blows have been found to cause such rods to shatter like glass—sometimes after a few hours work. This criticism applies to a few hammers of the first class mentioned but to a less extent because of their lower hammer velocity and smaller percussion reactions.

In analyzing the action of pile drivers, a wholly satisfactory basis has not been developed but it is probable that the driving effect depends on the velocity of the hammer at the end of its fall and also on the work developed by its fall. The latter factor is often considered the more important. In the comparisons which follow the author has shown both quantities.

The action of the steam upon the piston of a hammer of the second class is only to propel it at an added velocity proportionate to the steam pressure and to its maintenance or the freedom of its admission to the cylinder. As this force is applied to a falling weight, the effect is to accelerate the velocity of fall. The velocity of the hammer at the end of the stroke in such a hammer may be computed from the familiar formulas for velocity of falling bodies, if one substitutes for the acceleration due to gravity an acceleration due to gravity and to steam pressure. Then there results:

$$V^2 = 2\,a\,h\,;\ a = G + \frac{P\,A}{M}\,;\ \text{and}$$

$$V = \sqrt{2\,G\left(1 + \frac{P\,A}{W}\right)\,h}$$

Where G = the acceleration of gravity, 32.2,
P = steam pressure in lbs. per sq. in.,
A = piston area in sq. ins.,
h = length of stroke in ft.
a = acceleration.
W = weight.
M = mass = W/G.

A 1,200-lb. hammer working on a 16-in. stroke and with 100 lbs. steam pressure effective would, by this formula, show a final velocity of 21 ft. per sec. This would be reduced in actual practice some 5 or 10% due to the friction of steam through the pipe lines and the valve gear, no matter how well designed the hammer is. Even then this is much greater than the final velocity of an ordinary steam hammer of the first class named, where the weight is merely raised by the pressure of the steam and allowed to drop by gravity alone. But it is much less than the limiting velocity obtained with a gravity-drop hammer falling through a distance of 45 ft. It should be remembered, too, that the blow can be varied, by throttling the steam, down to about that which would result from a gravity-drop machine of the same dimensions, in this case a theoretical final velocity of 9 ft. per sec.

The author has designed a hammer of this second type, which overcomes the objections made to the second type of steam hammer in particular and against steam hammers in general. To prevent percussion reactions affecting the piston rod, this is made stationary and the hammer forms the cylinder. As the work is very severe and the concussion tends to loosen all bolts, nuts or fastenings, these have been eliminated as far as possible and the moving parts have been reduced to a rough and ready design. There is no delicate valve mechanism subject to the continual breaking found with some hammers which are often in the repair shop as long as in actual service. In the author's design, the cylinder and hammer is a heavy solid steel casting. It slides freely on guides which are part of the frame and its mass is such as to readily absorb the effect of percussion. The lower end or pene strikes upon a loose anvil, or dolly block, also of steel, resting on top of the pile. The pene is made of such large area that it is not injuriously upset by the effect of repeated blows. The piston and piston rod are stationary and rigidly connected to the valve chest which, in its turn, is securely bolted to the frame. The piston rod is made of very large diameter, to allow channels to be bored through it. These channels admit the steam, alternately above and below the piston.

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†See Engineering News, 1904, July-Dec., p. 378.

COMPARISON OF PILE DRIVERS.

	Weight of hammer.	Steam pressure, lbs. per sq. in.	Blows per minute.	Drop.	Final velocity, ft. per sec.	Work per blow, ft.-lbs.	Work per min., ft.-lbs.
Steam Hammer	3,000	...	60	20 ins.	10.35	5,000	300,000
Gravity-Drop	3,000	...	60	24 ins.	11.31	6,000	360,000
	3,000	...	60	30 ins.	12.70	7,500	450,000
Goubert Steam Hammer	800	50	180	10 ins.	12.4	1,920	346,000
6¼-in. cylinder	800	100	180	10 ins.	16.0	3,170	571,000
Goubert Steam Hammer	1,200	50	180	16 ins.	16.3	4,940	890,000
8-in. cylinder	1,200	100	180	16 ins.	21.0	8,260	1,485,000
	2,800	...	12	10 ft.	25.4	28,000	336,000
Gravity-Drop Hammer.	2,800	...	9	25 ft.	40.2	70,000	630,000
	2,800	...	6	45 ft.	53.6	126,000	756,000

$$\text{Velocity} = \sqrt{2\,c_1\left(1 + \frac{PA}{W}\right)h} \quad ; \quad \text{Work} = (W + PA)h \quad ; \quad \text{Friction Neglected}$$

This large diameter of piston rod gives added rigidity to the piston.

The admission of steam is controlled by a rotary valve in the chest at the top of the frame. This valve is a simple double-D type, actuated by a radial arm to the end of which is hung a weighted plunger. The cylinder has no permanent connection with the valve gear. At the end of the up stroke, it strikes the plunger and rotates the valve sufficiently to admit steam under the piston. The cylinder is then forced downward and strikes the blow. The concussion of the blow is sufficient to cause the slowly moving plunger, attached to the valve arm, to suddenly fall, thereby quickly reversing the valve, opening the exhaust and admitting steam for the up stroke. A buffer spring limits the fall of the valve plunger, and protects it from injuries. In this design the parts are all heavy and easily accessible. All castings are of open-hearth steel and are practically indestructible.

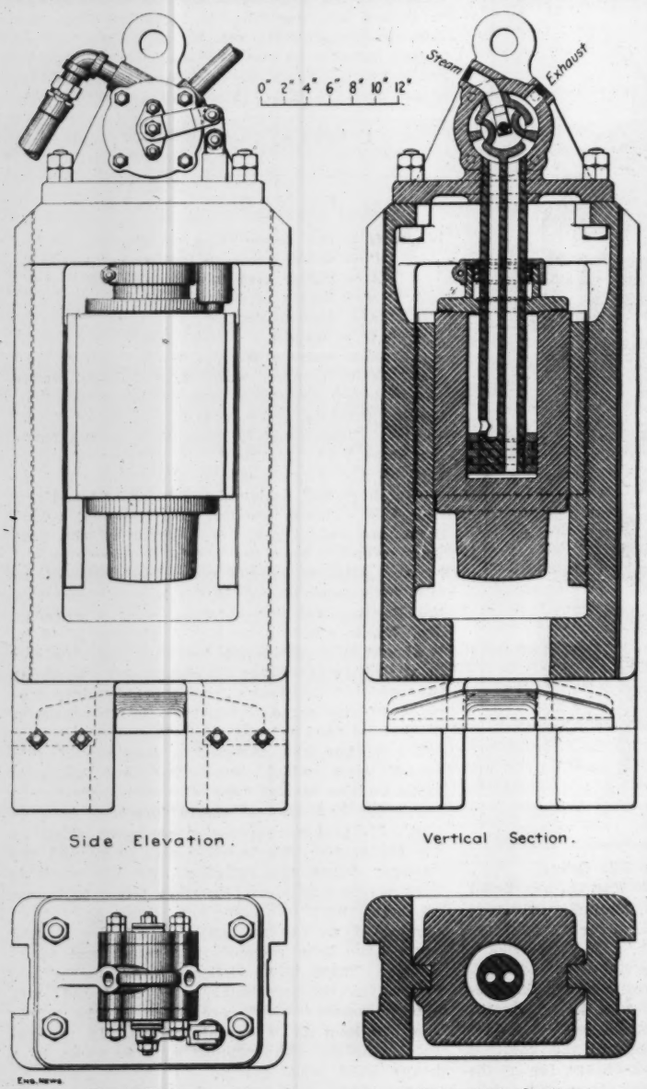

FIG. 2. DETAILS OF THE GOUBERT STEAM PILE DRIVER.

It is arranged to slide the whole frame on leaders if required, and an eye is provided on the top of the chest for suspension from a derrick. The length of the dolly block is such as to permit driving two interlocking sheet piles at the same time, and it is made in the form of a cross, so that corner sheet piles may be readily driven. Round piles from 9 ins. to 20 ins. in diameter may be taken in, according to size of machine.

In order to have a basis for figuring the load a pile will bear, it is customary to specify that it shall be driven until it will sink only a given distance under the blow of a certain weight falling a certain distance. For instance, it may be required that with a 2,000-lb. hammer falling 10 ft. the pile must not sink more than 0.5 in. under the blow. The query arises as to how one can similarly ascertain the bearing power of a pile driven with a steam hammer. The query is easily satisfied if one accepts a basis of comparison involving the energy of the blow, or blows, required for a given penetration.

In the above problem the energy of the blow is 20,000 ft.-lbs. Consider the 800-lb. hammer of the steam driver shown in the accompanying table. The work of a single blow is shown to be 3,170 ft.-lbs. The ratio of these quantities is:

$$\frac{20{,}000}{3{,}170} = 6.3,$$

so that 6.3 blows of the steam-driven hammer will drive the pile 0.5 in. With a rapidly working hammer, one cannot count a small number of blows. However, if one knows that the hammer makes say 180 blows per minute then the depth to which it might be specified that the pile should sink in the last minute would be,

$$\frac{180}{6.3} \times 0.5 = 14.25 \text{ ins.}$$

It should be remembered that the ground is kept "alive" by the rapidity of the blows and the bearing power of the pile will be increased after driving, as the soil settles in about the pile.

Experience with Pipe Culverts of Corrugated Iron.

To an engineer of the old school, accustomed to build always with an eye to permanence and solidity, the idea of putting a culvert of thin corrugated iron under an earth embankment may seem like a crude makeshift, which ought to be condemned offhand without discussion. Very likely the first use of corrugated iron for culverts was a makeshift; but experience appears to show that under certain conditions culverts of this apparently flimsy construction have made good.

Such culverts are exceedingly cheap, are very light to transport and place and have so much elasticity and "come and go" that they will stay in place when unequal settlement occurs where a much heavier culvert would be cracked and broken. For temporary work such culverts are especially advantageous, as they are cheap to place and can be recovered if the bank is removed.

The rapid rusting out of sheet iron or steel exposed to the alternate wetting and drying that a culvert receives naturally occurs as a foremost objection to corrugated iron culverts, but some of these metal culverts are said to have been in service for some 15 years. By using a special grade of iron of high purity such as that described in our issue of Jan. 6, the resistance to corrosion is expected to be so greatly increased that the culverts may fairly be classed as permanent construction.

Many railways are using these culverts, but most of those from which we have information are doing so experimentally. One steam railway which is using the "ingot iron" culverts (noted below) experimentally, states that the reasons for their use are the convenience in handling and the cheapness. This road has six culverts of 24 ins. to 36 ins. diameter which have been in use about 18 months; this time has not, of course, been sufficient to develop corrosion, but the chief engineer has personal information of a similar culvert (not of ingot iron, however,) which has been in actual service for 11 years without apparent deterioration. One 30-in. and one 36-in. culvert collapsed, but investigation showed that the trouble was due to the culvert having been placed on a very soft and wet foundation without proper tamping or the usual precautions to prevent settlement. The original diameter was restored with jacks and the culverts then backed up with concrete on the outside, and they are now in good condition. The tops of these culverts are within about 12 ins. of the bottom of the ties.

The engineer in question states that the proper method of laying the culvert is to lay it on an unyielding foundation and ram it thoroughly with the best material at hand. He considers that if any other precautions beyond these are taken, the use of this type of culvert would not be justifiable, as other types would then be cheaper. Thus for culverts of 18 ins. to 36 ins. diameter, clay pipe heavily encased in cheap concrete is cheaper than the sheet metal pipe; and above 48 ins. diameter, a plain concrete box with reinforced-concrete or creosoted timber top is the cheapest. The cost per foot for culverts of rolled "ingot iron" sheets and cast-iron pipe is compared by him as follows:

Culvert diameter, ins.	Cost per lin. ft. Ingot iron.	Cast-iron pipe.
18	$1.40	$2.15
24	2.00	3.20
36	3.50	5.50
48	5.00	8.50

On another railway, the sheet metal pipe culverts have been used for placing inside old wooden box culverts. The old culverts are in

high banks, and the above method of renewal was adopted in order to avoid the expense of digging into the bank, or the alternative of reducing the waterway by building new wooden culverts inside the old ones. In 1900, 20 culverts were renewed in this way, with pipes 16 ins. to 36 ins. diameter. In 1908, the grade was revised at one of these places, and the pipe taken out was found to be in good condition. For culverts less than 24 ins. diameter, cast iron is considered to be cheaper. During 1909, this road has used reinforced-concrete pipes for culverts. The pipes are 8 ft. long, with bell and spigot joints. This is said to have reduced the cost 50% for culverts 30 ins. diameter and over, and the opinion is expressed that for new construction work reinforced concrete will take the lead in future on account of its cheapness and durability.

THE ACME CULVERT.—The Acme corrugated metal culvert, made by the Canton Culvert Co., of Canton, O., is so designed as to enable it to be shipped either set up complete, or in semi-circular sheets nested together and ready to be erected in the field. The sheets

CONSTRUCTION OF A RAILWAY CULVERT OF CORRUGATED METAL SHEETS.

(This is being erected in the field, but in many cases the culverts are shipped as complete pipes [in one or more lengths].)

have interlocking flanged ends, which are bolted together, forming two longitudinal ribs. This feature is shown clearly in the accompanying cut, and the culvert is so made that the flanges provide ample bearing surface, while the bolts prevent spreading at the joint. The circular seams are made by lapping the corrugations, the upper and lower sheets breaking joints. An advantage of this construction is that the sheets can be nested and packed in bundles for convenience of transportation. For special purposes, flat corrugated bottom plates may be used, making a culvert of semi-circular section.

Perforated corrugated plates are used in some cases for the upper half of drains or culverts of both circular and semi-circular section, the plates being made for diameters of 8 ins. to 36 ins. These plates have ½-in. holes of 4 ins. pitch (staggered) in the valleys of the corrugations. After being punched these plates are galvanized by the hand-dipped process so that there are no exposed edges.

The sheets are made of a special galvanized material, termed "No-Co-Ro" metal, and the company states that the manufacture (from the furnace to the finished product) is under its supervision and direct management in its local mill connections. In the general characteristics the metal is similar to the "Ingot iron" noted below. Comparative tests with solutions of sulphuric acid are said to have showed a rust-resistance five times higher than that of charcoal iron and over sixteen times that of steel.

The "Acme" culverts have been used extensively in this country, and to some extent in other countries. They are made in diameters of 8 ins. to 6 ft., with metal of Nos. 16, 15 and 14 U. S. gage for the smaller sizes, and Nos. 12 and 10 gage for the larger sizes. The sheets are in 26-in. lengths, with 2-in. laps, making a finished length of 24 ins. It is estimated that when properly laid a life of 20 to 25 years may be expected.

THE WATSON CULVERT.—The Watson culverts are made of corrugated sheets of "Ingot iron," made specially for the purpose, and thoroughly coated with spelter. They have riveted lap joints for the horizontal seams. They are of 8 ins. to 7 ft. diameter, made ordinarily in 26-in. lengths, the joints between the sections being made by interlocking and riveting the end corrugations. The pipe is built at the shops, and ordinarily the culvert is made and transported in one piece. Long culverts, however, are made in two or more sections to facilitate handling; the joint in the field is made by interlocking the end corrugations and putting around it an iron band which is drawn tight and secured. Special advantages are claimed from the continuity of the culvert, so that it will not separate or collapse.

The "ingot iron," which is made specially by the American Rolling Mill Co., of Middletown, O., for the manufacture of culverts of the Watson type, is a special grade of metal whose character and development were described in our issue of Jan. 6.

In a test of a bare 12-in. culvert at the Cleveland shops of the Lake Shore & Michigan Southern Ry., no deflection appeared under a load of 10,000 lbs.; with a load of 15,000 lbs. (6,021 lbs. per sq. ft. of diametrical area), the deflection was ¼-in., and the specimen collapsed at 23,000 lbs. (10,620 lbs. per sq. ft.). This specimen was 12 ins. diameter, 26 ins. long, weighing 8.5 lbs. per ft.; its thickness was 0.058-in (No. 17 U. S. gage), and its corrugations were 15-32-in. deep, with a pitch of 2¾ ins. In a test made at the University of Illinois, a total weight of over 184,000 lbs. was applied upon a 36-in pipe 8 ft. long, giving a load of over 23,000 lbs. per lin. ft. In making this test the pipe was surrounded completely with about 12 ins. of sand, and the load applied at the top by means of hydraulic jacks through a frame and saddle. The load mentioned was the maximum which the pipe would carry under the conditions; although the pipe had deflected considerably there was no fracture in it, and it was still in good condition to carry water.

The first Watson culverts were installed at Crawfordsville, Ind., 15 years ago, and are said to be still in perfect condition. These, however, were made from a puddled iron and were not galvanized. It is estimated that those made from the galvanized sheets of "ingot iron" will have a much longer life.

Annual Meeting of the New England Water Works Association.

By CHARLES W. SHERMAN,* M. Am. Soc. C. E.

The annual meeting of the New England Water Works Association was held at Hotel Brunswick, Boston, on Wednesday, Jan. 12, 1910, with an attendance of about 130. After the usual routine business, Mr. Richard A. Hale, in behalf of a committee, read a memoir of the late E. H. Gowing. The retiring President, Mr. Robert J. Thomas, Superintendent of the Lowell Water-Works, then delivered the president's annual address. He noted that there had been a net gain of membership of 19 in the past year; that the association had lost eight of its members and one honorary member by death, and that its financial condition was about the same as at the beginning of the year. He made some suggestions for improvement in the manner of transacting some of the association's business, and closed by announcing that the executive committee had just voted that the next annual convention should be held at Rochester, N. Y., Sept. 14 to 16.

The Secretary, Mr. Willard Kent, reported that the total membership in all grades is now 715; also that the receipts from current sources during the year amounted to $5,104. The Treasurer, Mr. L. M. Bancroft, reported a statement of assets and liabilities, showing net assets in excess of $5,000. The tellers of election reported the result of the ballot for officers for 1910. The principal officers elected were:

President, George A. King, Superintendent of Water-Works, Taunton, Mass.
Vice-Presidents, Allen Hazen, New York City; E. M. Peck, Hartford, Conn.; M. F. Collins, Lawrence, Mass.; Leonard Metcalf, Boston, Mass.; Irving S. Wood, Providence, R. I.; Frank A. McInnes, Boston, Mass.
Secretary, Willard Kent, Narragansett Pier, R. I.
Treasurer, L. M. Bancroft, Reading, Mass.
Editor, Richard K. Hale, Boston, Mass.

Mr. Marshall O. Leighton, Chief Hydrographer of the U. S. Geological Survey, presented a paper upon

Government Policy in Relation to the Regulation of Water Powers.

Within the last few years there has developed an important new principle in the political economy of nations—one involving a wide range of constructive engineering, statesmanship and jurisprudence. The matter of the proper control of water powers was formerly merely a local problem, since such power could be used only where it existed, but since the development of long-distance electrical power transmission the problem has assumed national scope. Such power may now be considered a public utility and accordingly subject to such public regulation as other public utilities are receiving. Its recognition as a public utility implies that the public retains a right of control. This has, however, not generally been recognized by legislative act. In most states, the conditions are exactly the same as they were years ago before long-distance power transmission was dreamed of. The country as a whole has no policy in this matter. The older states depend entirely upon the common law, which has already proved inadequate to properly deal with the matter.

It is inevitable that there should be an extensive consolidation, or pooling of interests, in the development of water powers supplying any region, or a "water-power trust," as it may be called. Only by consolidation and joint operation can power be economically developed and distributed so as to supply the large district which, with electrical transmission, may be tributary to one group of water powers. This offers large possibilities of manipulation, and public interference of some kind is inevitable. Legislative regulation of the development and distribution of power therefore becomes necessary. It is exceedingly difficult to frame a law which will accomplish only laudable results. Some of the western states, where the principle of "prior appropriation of water" is recognized in the organic law, are in much better position in this matter than the eastern states, which depend entirely upon the common law. Much discretion must be

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used in regulating rates and earnings of such water-power companies. In some cases, particularly in the mining regions where the only use for power is in connection with the mines, the risks in such a development are great, and perhaps even 25% net earnings are not unreasonable. In other localities, where there is a steady demand for power, 5 or 6% may be equitable. Any regulation of price must take all local conditions, distance of the market, etc., into consideration, and it must be particularly recognized that there is a great difference between capitalization and cost of plant in many cases.

In some parts of Europe suggestive and instructive legislation has been enacted during recent years having to do with the matter of water powers. Some of the most interesting and instructive experiences have been had in Switzerland, where in 1908 a constitutional amendment was passed giving the Federal Government control over all water-power matters. In Italy, also, much progressive legislation has been enacted and all water powers are developed under lease, with an annual rental of 3 fr. (60 cts.) per HP. to be paid to the government. All applications are scrutinized by a permanent expert commission. In France, too, much has been accomplished and no water power can be developed without a permit from the government.

Much of this foreign experience seems to point to a course which we must necessarily follow, and yet most of it to our present ideas seems extremely un-American.

In discussion, Prof. D. C. Jackson (Boston) congratulated the association on having so valuable and instructive a paper presented before it. He called especial attention to the necessity, under present conditions in this country, of encouraging rather than discouraging water-power developments, reminding the members that a number of large hydraulic undertakings started within recent years have passed through foreclosure, meaning practically total loss to the original promoters. Professors George F. Swain and Dwight Porter (Boston) also spoke briefly in discussion.

Typhoid Epidemic at Maidstone, England.

The second paper was by Prof. Wm. P. Mason (Troy, N. Y.) and gave some hitherto unrecognized facts in regard to the epidemic of typhoid at Maidstone, England—at least, facts which are not generally known in this country. It seems that Maidstone is the center of a large hop-picking district; that the soil is clayey and in times of drought becomes very deeply fissured, and that the water is a ground water collected by open-jointed tile laid a few feet below the surface of the ground. The hop-pickers come largely from the slums of London and other large cities, and during the picking season live almost anyhow, in camps, without any sanitary facilities. Under these circumstances, the first rain following a prolonged drought washes much contaminated material into the cracks of the soil, which must find its way almost directly to the collecting pipes of the water-works system. The rise of the epidemic followed directly after such a heavy rain succeeding a drought, with, of course, the usual two weeks period of incubation.

Other Proceedings.

A preliminary report of the committee to formulate standard specifications for fire hydrants was presented by the chairman, H. O. Lacount [Engineering Inspection Department, Associated Factory Fire Insurance Cos., Boston, Mass.] This committee has been in existence for more than two years and has had many meetings and conferences, but has not succeeded in getting very much information from members having had experience, and up to this time has not succeeded in getting any conference with the manufacturers. A letter, however, had just been received from an association representing a conference of manufacturers, asking that final action be deferred until their committee could confer with that of the association, and Mr. Lacount therefore asked that the suggested specifications be considered as a report of progress only, but that they be published in the Journal in order to get the widest possible discussion, and that the matter be referred back to the committee for a final report at some later date. This reference was accordingly made and the suggested specifications were briefly discussed by a few members.

Notes from Engineering Schools.

RENSSELAER POLYTECHNIC INSTITUTE.—A new regulation of the Faculty which will take effect at the beginning of the next academic year makes provision for the acceptance of all work, included in the first two years at Rensselaer, which may have been covered in other technical schools or colleges of recognized standing—with the exception of differential and integral calculus. The rule also provides that two years' work in any modern language will be accepted as a substitute for the course in French which has heretofore been insisted upon. The Institute has therefore demanded that all applicants for advanced classes should undergo examinations in every subject covered by the curriculum of the first year or other years, notwithstanding the fact that the applicant may have gone over these courses elsewhere in the most thorough manner. It is expected that this action, in connection with higher entrance requirements, will bring to the school men who have taken some broad course as a preliminary to the purely technical engineering courses.

HARVARD UNIVERSITY.—The much discussed changes in the system of elective studies in this university, made to cause students to take most of their work in some one field and to distribute the rest of their courses, are explained in the following extracts from the rules recently adopted by the faculty:

Every student shall take at least six of his courses in some one department, or in one of the recognized fields of distinction. In the latter case four must be in one department. Only two of the six may be courses open to Freshmen or distinctly elementary in character.

For purposes of distribution all the courses open to undergraduates shall be divided among the following four general groups. Every student shall distribute at least six of his courses among the three general groups in which his chief work does not lie, and he shall take in each group not less than one course, and not less than three in any two groups. He shall not count for purposes of distribution more than two courses which are also listed in the group in which his main work lies.

(1) LANGUAGE, LITERATURE, FINE ARTS, MUSIC.
  (a) Ancient Languages and Literatures.
  (b) Modern Languages and Literatures.
  (c) Fine Arts, Music.
(2) NATURAL SCIENCES.
  (a) Physics, Chemistry, Astronomy, Engineering.
  (b) Biology, Physiology, Geology, Mining.
(3) HISTORY, POLITICAL and SOCIAL SCIENCES.
  (a) History.
  (b) Politics, Economics, Sociology, Education, Anthropology.
(4) PHILOSOPHY AND MATHEMATICS.
  (a) Philosophy.
  (b) Mathematics.

A committee on electives, having nine members, was given authority to arrange various courses under the different groups and sub-groups by agreement with the departments giving the courses. Prescribed courses do not count for concentration or distribution. The committee is allowed to arrange courses for earnest students who desire to change their early plans and for those who can show well distributed courses not conforming exactly to the general rules.

THE FAMOUS GARDEN OF THE GODS, Colorado Springs, Colo., has become the property of that city. As many of our readers remember to their lasting pleasure, this garden presents some most remarkable instances of rock weathering into fantastic shapes. The area comprised within the garden is some 430 acres. The land was bought by Mr. Charles E. Perkins, a former president of the Chicago, Burlington & Quincy R. R., as long ago as 1879. In accordance with his expressed wishes, the land has been conveyed to the city by his heirs, with the provision that it shall be forever used as a free public park. It may be added that Mr. Perkins always kept the park open to the public and that he resisted many offers to sell or rent it at high figures. The tract has been placed in the hands of Messrs. D. V. Donaldson, Henry LeB. Wills and Henry C. Hall, as trustees for the city.

A NITROGLYCERINE MAGAZINE EXPLODED Jan. 12 at Brandon's Ferry, Pa., killing three men and a team of horses.

AN EXPLOSION OF GAS at Bloomington, Ill., Jan. 10, in the plant of the Union Gas Co. wrecked the main building, killing three men and injuring six others. The explosion followed an attempt to make an extension of the capped end of a 10-in. main in the water-gas plant. The cap had been removed from the end of the main and replaced temporarily by a rubber bag. The bag was blown off and the escaping gas ignited.

THE STEAMSHIP "CZARINA" WAS WRECKED on the bar at the mouth of Coos Bay, Ore., Jan. 12, in a heavy gale. Of the 31 persons on board, only one reached shore alive. The "Czarina" was owned by the Southern Pacific Co. and left Marshfield, Ore., on the date of the disaster bound for San Francisco. She was built in England in 1883. She was sunk in Chesapeake Bay nine years ago but was easily raised and remodeled.

A SMALL RAILWAY BRIDGE COLLAPSED two miles east of Wister, Okla., under a westbound freight train on the Chicago, Rock Island & Pacific Ry. Ten cars, two of which contained chemicals and three oil, fell into the Potean River and caught fire. Five tramps, imprisoned in the wreckage, were burned to death.

A BUTTING COLLISION AT KEYSTONE, IOWA, Jan. 16, between the Overland Limited and another passenger train on the Chicago, Milwaukee and St. Paul Ry., caused the death of one passenger and the injury of ten other persons. The eastbound passenger train was to take the siding at Keystone to let the Overland pass. A freight train occupied one end of the siding and the eastbound passenger, running past to enter the siding from the other end, was struck by the Overland.

A WASHOUT OF 93 MILES OF TRACK of the San Pedro, Los Angeles & Salt Lake R. R. was caused by floods resulting from the tremendous rainfall of Jan. 1 in southern California and Nevada. The principal damage was done by the Meadow Valley Wash, whose valley the railway follows through Nevada. Reports state that a large number of employees in the clerical and shipping departments of the San Pedro, Los Angeles & Salt Lake have been dismissed for an indefinite period and that the road is not expected to resume regular operation until September, 1910. It is unofficially stated that the railway will be only temporarily rebuilt in the present location, but that permanent construction will be undertaken over a route which will avoid the dangerous Meadow Valley. Three years ago the railway suffered heavy damages from washouts in the same district which put a stop to all traffic for several weeks.

The San Gabriel River, near Los Angeles, widened its channel at many points under the influence of the heavy rainfall of Jan. 1 and in some cases even completely changed its course. The Pacific Electric Ry. lost a number of bridges as a result of the San Gabriel flood and the lines of the Southern Pacific and the Atchison, Topeka & Santa Fe Ry. were somewhat affected, although much less seriously.

AN ICE JAMB ON THE MISSISSIPPI at St. Louis broke on Jan. 13 and piling up along the river front, wrecked wharves and shipping to the extent of $150,000 damage. Ice has been jambed all along the Mississippi and Missouri for the past month, but the warm weather of last week tended to thaw the gorges and to cause them to break. Gorges in the Missouri, above St. Louis, broke in the morning of Jan. 13 and the water released thereby swept down toward the city. Fortunately one of the heaviest gorges below the city, that at Chester, went out in the afternoon, so that the water at St. Louis, which by that time had reached the limit of safety, was allowed to go out, but in going out the huge ice blocks ripped and tore their way through the shore structures and the boats tied up to the wharves.

A HEIGHT OF 5,000 FT. was reached by Louis Paulhan on Jan. 12, driving a Farman biplane flyer at the Los Angeles (California) aviation meet. This beats the record of Hubert Latham (3,600 ft.) noted in Engineering News Jan. 13, made at Mourmelon, France, on Jan. 7. On Jan. 18, Paulhan made a record cross-country flight of 47 miles in adverse winds in 1 hr. 2 min. 42⅘ sec.

THE FREIGHT-CAR SITUATION on Jan. 5 was but little changed from that two weeks before, though incomplete reports make the statement of the American Railway Association imperfect. The probable surplus of cars on Jan. 5 was 60,000 to 65,000, an increase of some 5,000 in two weeks. Simultaneously the shortages at various points have decreased by over 5,000 cars, to 15,000 or 20,000. The general situation is a slacker demand for cars, and slightly reduced business.

AN AUXILIARY SALT WATER SYSTEM for the fire protection of Oakland, Cal., has been built by that city

A pumping station equipped with duplicate gasoline engines and pumps, having a capacity of 1,000 gals. per min. each and giving a pressure of 150 lbs. per sq. in. at the hose nozzles, has been installed on Lake Merritt, a body of salt water connected with the bay by an inlet. The pipe system has been arranged to encircle 70 blocks in the business district. Additions to this system are proposed at a later date. The work was carried out under the charge of Mr. P. F. Brown, Assistant City Engineer of Oakland.

THE SHOSHONE DAM, under construction for several years past by the U. S. Reclamation Service near Cody, Wyo., was completed at 2 a. m., Sunday, Jan. 16. An illustrated article describing recent progress on this interesting structure was published in Engineering News of Dec. 9, 1910. The total height of the dam from the lowest part of the foundation is 328.4 ft., but so remarkably favorable was the site chosen that the canyon width at the crest is only 180 ft. The dam curves upstream with a center-line top radius of 150 ft. It is built of concrete, with hand-placed stone, up to 25% of the total volume of the masonry, embedded. The structure is 108 ft. thick at the base, continues of that thickness for about 80 ft., or to the level of the bed of the stream, and diminishes to a thickness of 10 ft. at the crest. Mr. F. H. Newell, M. Am. Soc. C. E., is Director, and Mr. A. P. Davis, M. Am. Soc. C. E., is Chief Engineer of the U. S. Reclamation Service. Mr. H. N. Savage, M. Am. Soc. C. E., is Supervising Engineer in Charge of the Northern Division of the Service, with offices at Helena, Mont., and Mr. D. W. Cole, M. Am. Soc. C. E., was Engineer at the dam.

A COMPETITION FOR CONCRETE RESIDENCE DESIGN has been opened by the Pittsburgh Architectural Club. The problem is to design a suburban concrete residence with a garage, using, wherever possible, concrete and cement construction. The house and garage together must not contain more than 50,000 cu. ft., and must contain room for a family of five persons, three adults and two children, and two servants. Prizes, offered by the Universal Portland Cement Co., aggregate $500. Information may be had from E. B. Lee, 732 Millvale Ave., Pittsburgh. Plans must be submitted by Feb. 16, 1910.

AN APPEAL TO THE PUBLIC for franchise privileges is being made through newspaper advertising by the Terminal Railroad Association of St. Louis. The Association has had introduced into the Municipal Assembly of St. Louis certain ordinances granting the Association rights and privileges on the streets of the city in connection with the enlargement of the railway terminal facilities there, and in order to inform the public of the desirability of the changes and the propriety of the ordinances, is using an advertising page of the local newspapers. This advertisement sets forth the terms of the ordinances and the claims of the Association, and appeals to the public to influence the members of the Municipal Assembly to pass the ordinances.

SUBWAYS FOR THE CANADIAN CITIES, Montreal and Toronto, are under serious discussion. In the former city considerable publicity has been given to a scheme which contemplates a six-track subway from Notre Dame de Grace in the west end of the city to Maisonneuve at the extreme east end, with branches to connect with all the railway stations in the city. This scheme also includes a double-track tunnel under the St. Lawrence River, affording connection with the south shore. In Toronto, by a vote of 19,261 for to 10,697 against, the taxpayers on Jan. 1 of this year authorized the city council to make the necessary application to the Ontario government for authority to allow the city corporation to establish a system of subway and surface railway lines running from the downtown portion out to the residential portions of the city.

PANAMA CANAL EXCAVATION during December, 1909, totaled 2,811,681 cu. yds. for the 26 working days, a daily average of 108,142 cu. yds. The rainfall dropped off slightly from the previous month, but reached the rather high figure of 15.85 ins. The amount of concrete laid during the month was 56,498 cu. yds., and 320,510 cu. yds. of fill were placed in dams.

THE CHARLES RIVER DAM, between Boston and Cambridge, saved the Back Bay District of Boston from flood damages at the close of 1909. The following statement on the subject was prepared by Messrs. Henry D. Yerxa and Joshua B. Holden, of the Charles River Basin Commission:

Opportunity has been offered within the past week to test the work which this Commission has done in the construction of the Charles River Dam and its appurtenances. The combination of a high range of tides and a storm has produced in Charles River below the dam a height of water greater than was experienced in 1851, when Minot's Ledge Lighthouse was destroyed. The tide of 1851 was the highest tide of which record has been kept in the vicinity of Boston. Formerly, high tides 2 ft. or more below the extraordinary tide of last Sunday morning had caused a flooding of cellars and great damage of property not only along Beacon St. and in the territory immediately adjacent to the river, but in the Park Square district and extending for a long distance toward the South End.

The dam and its appurtenances stood the test of this tide, and whereas the people along other portions of the water front suffered severely, the residents in the territory bordering on Charles River Basin on both sides of the river were saved a repetition of an injury similar to those previously experienced. In one day the dam has been able to save damages to property which in the aggregate would have amounted to a considerable fraction of its cost. For illustration, it may be said that if it had not been for the dam there would have been about 2 ft. of water over the entire length of the street back of Beacon St.

A STAND-PIPE WAS CONDEMNED for excessive stresses recently at Brockton, Mass. It is 62 ft. in diameter and 59.35 ft. high. The plate is of steel, but the rivets may be iron. The lowest ring is 11/16-in. thick. The vertical joints are double-riveted, with ¾-in. rivets driven by hand, spaced 2.87 ins. on centers in each row. When the pipe was full, the circumferential stress in the plate was over 19,000 lbs. per sq. in., while the rivet shear amounted to 31,000 lbs. per sq. in. (nominal diameter counted). In spite of these dangerously high stresses the pipe lived for about 20 years without failure. It seems to show relatively little depreciation by rusting, according to City Engineer Charles R. Felton, who gave us the figures quoted. Mr. Felton also says:

The pipe was filled twice daily, generally to a point where it actually ran over, during the first 14 years, and since then has been filled occasionally to its full height but usually to within two or three feet of the top.

It appears therefore that the pipe actually experienced the full water-pressure, hence the above-computed stresses. The original specifications fixed the plate thickness, but did not specify pitch or size of rivets. Mr. Felton reported the structure unsafe when he discovered the high shear in the joint rivets, and it is now out of use.

Personals.

Mr. William Mahl has been elected President of the Texas & New Orleans R. R., succeeding E. H. Harriman, deceased.

Mr. Frederick N. Pease, Assistant Chemist of the Pennsylvania R. R., has been appointed Chemist to succeed the late Dr. Charles B. Dudley.

Mr. Henry R. Beebe, a graduate of the Rensselaer Polytechnic Institute, class of 1904, has been appointed Commissioner of Public Works of Utica, N. Y.

Mr. R. A. Jackson has retired from the presidency of the Rock Island Co. and has been succeeded by Mr. Robert Walker, formerly Assistant General Counsel of the Rock Island system.

Mr. W. E. McClintock, M. Am. Soc. C. E., has resigned his position as Chief Engineer of J. B. Taylor & Co., of New York City, and will open offices in New York City as a consulting engineer.

Mr. O. Cornelison, General Superintendent of the Chicago & Great Western R. R., has resigned and that office has been abolished. Its duties will be assumed by Mr. H. J. Slifer, General Manager.

Mr. W. F. Bay Stewart has resigned his position as President of the York Rys. Co., of York, Pa., and has been succeeded by Mr. Gordon Campbell, formerly with the Washington Ry. & Electric Co., Washington, D. C.

Mr. R. C. Carpenter, M. Am. Soc. M. E., Professor of experimental engineering at Cornell University, and Mr. E. H. Faile, Jun. Am. Soc. M. E., have formed a partnership for the practice of mechanical and electrical engineering with offices at 68 William St., New York City. The partnership is announced as a temporary arrangement.

Mr. H. S. Graves, Director of the Yale Forestry School, has been appointed Chief Forester of the United States to succeed Mr. Gifford Pinchot. Mr. A. F. Potter has been appointed Assistant Forester. Mr. Graves is a graduate of Yale University, class of 1892, and has been at the head of the Yale Forestry School since 1900. He was Assistant Chief of the Bureau of Forestry under Mr. Pinchot in 1898-1900.

Mr. Robert W. Gay, Jun. Am. Soc. C. E., formerly Associate Professor of civil engineering at the State Agricultural College, Fort Collins, Colo., has entered the service of Hunt & Hunt, architects, of New York City, as Assistant Superintendent of Construction with headquarters at Port Washington, Long Island. Mr. Gay was recently connected with Viele, Blackwell & Buck, consulting engineers, of New York City.

Mr. M. J. Butler, M. Can. Soc. C. E., has resigned his position as Deputy Commissioner of Railways and Canals of Ottawa, Ont., to become General Manager and Second Vice-President of the Dominion Iron & Steel Co. and the Dominion Coal Co. Mr. Butler's salary as Deputy Commissioner is given in newspaper reports as $8,000, and in his new position as $25,000. Mr. Butler will continue to act as Deputy Commissioner for a few weeks pending the selection of his successor.

Mr. H. K. Barrows, M. Am. Soc. C. E., and Mr. C. B. Breed, Assoc. M. Am. Soc. C. E., have entered into partnership for the general practice of civil engineering under the firm name of Barrows & Breed. Mr. Breed, now Assistant Professor of civil engineering at the Massachusetts Institute of Technology, has carried on for some time a consulting practice on railway grade crossing elimination, general masonry construction and litigations involving railway, highway and foundation construction. Mr. Barrows' appointment to succeed Mr. Wm. E. Mott as Associate Professor of hydraulic engineering at the Massachusetts Institute of Technology was noted in our issue of Dec. 9, 1909.

Announcement has been made by the War Department of the following changes to take place in the Engineer Corps of the Army to become effective about Feb. 10:

Maj. George P. Howell, now on duty under the Chief of Engineers in Washington, will be put in charge of river and harbor and fortification work in the Galveston engineer district; Capt. James C. Oakes, now in charge of that district, will be assigned to take charge of the second Cincinnati district, relieving Lieut.-Col. James G. Warren. Maj. Robert R. Raymond, now on duty in the Engineer School in Washington, will be detailed to take charge of the river and harbor work in the Wilmington engineer district, relieving Capt. Lewis H. Rand, who will be put on duty at the barracks in Washington. Lieut.-Col. William E. Craighill is relieved from his present duties and ordered to report to the Secretary of Commerce and Labor for duty as Engineer Secretary of the Lighthouse Board, relieving Col. Thomas L. Casey, who will report for duty to the Chief of Engineers.

Changes in the corps of civil engineers of the Navy have been made as follows, by orders issued Jan. 8:

Mr. A. J. Menocal has been ordered home to await orders; Mr. James W. G. Walker has been ordered to the Pensacola naval station; Mr. Lyle F. Bellinger, to Philadelphia yard; Mr. Roy F. Smith, to Rensselaer Polytechnic Institute, Troy, N. Y.; Mr. Ralph Whitman, to Bureau of Yards and Docks; Mr. Carrol Paul, to Norfolk yard, assistant to civil engineer at that yard; Mr. F. R. Harris, to New York yard as Civil Engineer at that station, on detachment of Civil Engineer Luther E. Gregory; Mr. P. L. Reed, to Bureau of Yards and Docks, Feb. 15; Mr. C. W. Parks, to Puget Sound yard; Mr. A. C. Lewerenz, to Pearl Harbor, on February sailing of steamer "Manchuria"; Mr. F. T. Chambers, to Norfolk yard; Mr. George A. McKay, to Mare Island yard; Mr. A. C. Cunningham, detached from Norfolk yard and report to naval aid for duty as general inspector of public works; Mr. L. E. Gregory, to Portsmouth yard; Mr. J. V. Rockwell, to New York yard, as assistant to Civil Engineer Harris; Mr. C. D. Thurber, to naval station, Great Lakes, Chicago, March 14, as assistant to civil engineer; Mr. U. S. G. White, to Bureau of Yards and Docks, Feb. 9.

Mr. F. P. Abercrombie, Superintendent of the New York division of the Pennsylvania R. R., Mr. C. T. Dabney, Superintendent of the central division, and Mr. W. N. Bannard, Superintendent of the Maryland division, have been delegated as special agents on the staff of the General Manager at Philadelphia, Pa., to assist in investigations into various transportation problems. Mr. Abercrombie is a graduate of the Rensselaer Polytechnic Institute, class of 1873, and entered the service of the Pennsylvania R. R. in that year as an assistant supervisor. Mr. Dabney entered the Pennsylvania's service in 1900 as Superintendent of the Chautauqua division. Mr. Bannard, a graduate of the Massachusetts Institute of Technology, class of 1869, entered the Pennsylvania's service in September of that year as a rodman.

Mr. Bannard's place as Superintendent of the Maryland division, will be taken by Mr. A. J. Whitney, Jr., Superintendent of the Delaware division, who in turn will be succeeded by Mr. E. B. John, recently Principal Assistant Engineer of the Philadelphia, Baltimore & Washington R. R. Mr. A. B. Clark, Division Engineer of the Pennsylvania's Maryland division, will succeed Mr. John and will himself be succeeded by Mr. J. J. Rhoads, Division Engineer of the Philadelphia terminal division.

Mr. Dabney will be succeeded as Superintendent of the central division by Mr. N. W. Smith, at present Division Engineer of the middle division, whose place will be taken by Mr. J. C. Auten, Division Engineer of the West Jersey & Seashore R. R.

Mr. Abercrombie's successor as Superintendent of the New York division will be Mr. J. B. Fisher, Superintendent of Telegraph at the general office, Philadelphia.

Obituary.

William M. Lane, Superintendent of the Lancaster (Pa.) Gas Co. for the past 20 years, died Jan. 13 at the age of 75 years. Mr. Lane was born in Philadelphia, Pa.

Andrew Steele, General Superintendent of the Quebec Central Ry., died Jan. 10 at his office in Sherbrooke,

Que. Mr. Steele was about 65 years old. He was appointed General Superintendent when the road was first opened in 1875.

Lieut. Lardner Gibbon, U. S. N., retired, died Jan. 9 at his home in Holmesburg, Pa. Lieut. Gibbon was born at Philadelphia, Pa., in 1820 and was appointed a midshipman when about 15 years old. In the early fifties, he conducted an exploring expedition across the Andes Mountains from the coast of Peru and down the Madeira and the Amazon rivers. An account of this expedition, written by Lieut. Gibbon, was afterward published by the U. S. Government. Lieut. Gibbon was the original projector of the Madeira & Mamoré Ry. He retired from the navy shortly before the Civil War, during which he served in the navy department of the Confederate States.

James Sargent, President of the Sargent & Greenleaf Co., lock manufacturers, of Rochester, N. Y., died Jan. 12 at his home in that city. Mr. Sargent was born at Chester, Vt., in 1824. He became a partner in the Yale & Greenleaf Lock Co. in 1857 and in 1865 established himself in business in Rochester in the manufacture of locks of his own invention. He was the inventor of many different locks, including the Sargent time lock, and of the glass enameled steel tanks and vacuum pump used by the Pfaudler Vacuum Fermentation Co., of which he was President. He invented also an automatic electric railway signal and was President of the Gordon Railway Signal Co.

Clifford Buxton, M. Am. Soc. C. E., Chief Engineer of the Toledo & Ohio Central Ry., and the Zanesville & Western Ry., died Jan. 12 at his home in Toledo, Ohio, after an illness of several weeks. Mr. Buxton was born at Warren, Me., in 1844 and graduated in 1865 at the Rensselaer Polytechnic Institute. Upon leaving the institute, he entered the service of the Troy & Boston R. R. as a rodman. He became a division engineer of the Allegheny Valley Ry. in 1866, and in 1867 was made Principal Assistant Engineer of the Knox & Lincoln Ry., remaining in this position four years. During 1871 he served as a United States assistant engineer, but became Principal Assistant Engineer of the Cleveland, Mt. Vernon & Delaware R. R. later in the same year. He left the last named railroad in 1875 to take a similar position with the Scioto Valley Ry. Mr. Buxton first entered the service of the Toledo & Ohio Central Ry. (at that time the Ohio Central Ry.) in 1879 as Principal Assistant Engineer. He had been Chief Engineer since 1881.

Albert Stanley Riffle, M. Am. Soc. C. E., a consulting engineer, of Sierra Madre, Cal., died in that city Nov. 28. Mr. Riffle was born in Pennsylvania in 1860 and was a graduate of the University of Kansas. At the age of 26, he was placed in charge of bridge construction on the western division of the Northern Pacific Ry. and later became Chief Engineer of that division. In 1890, as Assistant Engineer under Mr. L. L. Buck, M. Am. Soc. C. E., he directed the construction of the Verrugas viaduct on the line of the Lima & Oroya Ry. about 52 miles from Callao, Peru. An illustrated description of the Verrugas viaduct, a cantilever structure with a central span of 235 ft. between piers, was published in Engineering News, May 9, 1891, p. 441. Mr. Riffle was afterward employed in connection with the construction of various other railway bridges in South America.

He returned to the United States and, after some work at the World's Columbian Exposition, Chicago, Ill., in strengthening some of the buildings during the installation of exhibits, he started the Oregon Bridge Co. in partnership with his brother, Franklin Riffle. Among the works undertaken by this company was the laying of a 28-in. water main under the Willamette River for the Portland, Ore., water-works, in 1893-4. A paper on the work of laying the main, presented by the two brothers before the American Society of Civil Engineers, was published in Vol. XXXIII. of the "Transactions," p. 257.

Albert Riffle was next employed as Engineer of Buildings on the San Francisco & San Jose Valley R. R., but soon left this company to associate himself as Hydraulic Engineer with the Excelsior Wooden Pipe Co., at San Francisco. He directed the erection of waterworks systems at Albuquerque, San Diego and other points on the Pacific Coast and in Hawaii. For some years preceding his death, Mr. Riffle had refrained from active practice on account of ill health.

Engineering Societies.

COMING MEETINGS.

AMERICAN SOCIETY OF INSPECTORS OF PLUMBING AND SANITARY ENGINEERS.
Jan. 20-22. Annual convention at Trenton, N. J. Secy., C. S. McCosker, Mobile, Ala.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 25-27. Annual meeting at Ottawa, Ont. Secy., C. H. McLeod, 413 Dorchester St. West, Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting at Cairo, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 8. Annual meeting at New Haven, Conn. Secy., J. Frederick Jackson, Box 1304, New Haven, Conn.

OHIO ENGINEERING SOCIETY.
Feb. 8-10. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 16. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, E. Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 16-17. Annual convention at Cedar Rapids, Iowa. Secy., A. H. Ford, Iowa City, Iowa.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Feb. 18-21. Annual convention at Chicago, Ill. Chairman, notification committee, O. U. Miracle, Minneapolis, Minn.

NATIONAL ASSOCIATION OF CEMENT USERS.
Feb. 21-26. Annual convention at Chicago, Ill. Pres., Richard L. Humphrey, Harrison Bldg., Philadelphia, Pa.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Feb. 24-26. Annual meeting at Chicago, Ill. Secy., D. J. Hauer, 721 Park Row Bldg., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
March 1-5. Annual meeting at Pittsburg, Pa. Secy., R. W. Raymond, 29 West 39th St., New York City.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 15-17. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

BROOKLYN ENGINEERS' CLUB.—At the meeting of Jan. 13, Mr. Geo. A. Orrok presented a paper entitled "The Blast Furnace as a Power Producer."

AMERICAN CHEMICAL SOCIETY.—At the meeting in Boston, Mass., Dec. 30, officers were elected as follows: President, W. D. Bancroft, Cornell University; councilors-at-large, A. D. Little, Boston, L. H. Beakerland, New York, and W. L. Dudley, Nashville, Tenn.; Treasurer, A. P. Hallock, New York; Secretary, Chas. L. Parsons, Durham, N. H.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the annual meeting in Ottawa, Ont., Sir Sandford Fleming and Mr. T. C. Keefer, Past-President, are expected to address the meeting at the 3 p. m. session, Jan. 25. The address by the retiring President, Mr. G. A. Mountain, will be given at the evening session on the same date. Jan. 26 will be given over to visits to power plants and other places of interest in the vicinity of Ottawa, concluding with a members' dinner at the Russell House in the evening. The final business session will be held Jan. 27.

NATIONAL ASSOCIATION OF CEMENT USERS.—The tentative program for the convention of the Association at Chicago, Ill., Feb. 21-25, 1910, has just been announced. In addition to the regular committee reports and topical discussions the following papers will be read: "The Use of Concrete for Farm Buildings from the Sanitary Standpoint," S. Cunningham, Jr.; "Laying Concrete Under Water—Detroit River Tunnel," Olaf Hoff; "The Groined Arch in Large Reservoirs," T. H. Wiggin; "Concrete for Maritime Structures," Chandler Davis; "Concrete in Barge Canal Work," R. S. Greenman; "Notes on Use and Cost of Concrete for Small Houses," R. C. Knapp; "Cost and Advantages of Concrete Drain Tile," J. H. Libberton, and "Use of Concrete in Protecting Wooden Piles Against Teredo," Ralph Barker. The meetings of the convention are to be held at the Auditorium Hotel and the exhibition, by the Cement Products Exhibition Co., at the Coliseum.

ARKANSAS VALLEY SOCIETY OF ARTS AND SCIENCES.—This new society was organized Dec. 18 at Pueblo, Colo., with a charter membership of about 30 members. Its object is to unite engineers, manufacturers and others interested in the development of the Arkansas Valley and the State of Colorado, and the society expects to take an active part in assuring the success of the National Irrigation Congress to be held at Pueblo in September, 1910. Meetings will be held on the second Saturday of each month and the annual meeting will be held the first Saturday in December. Officers were elected at the inaugural meeting as follows: President, R. M. Hosea, Pueblo, Colo.; Vice-Presidents, J. S. Greene, Pueblo, Colo., H. I. Reed, Colorado Springs, Colo, and H. E. Hedge, Garden City, Kan.; Treasurer, D. P. Gaymon, Pueblo, Colo.; Secretary, R. C. Smith, 421 Central Block, Pueblo, Colo.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the meeting of the Board of Directors held Dec. 16, 1909, a resolution was passed authorising the meetings and papers committee to arrange for a meeting of the institute at some suitable point in the South Atlantic States during the month of March, 1910. The committee has decided that the meeting shall be held at Charlotte, N. C., March 23-25. The program so far as arranged comprises the following papers: "Economics of Hydro-electric Plants," W. S. Lee; "Electric Drive in Textile Mills," A. Milmow; "Calcium Cyanamid and Its Relation to Water Powers," Charles H. Baker; "Gas Engines in City Railway and Light Service," E. D. Latta, Jr.; "Protective Devices for High-Tension Transmission Lines," L. C. Nicholson. In addition to a number of attractive social features, a tour of inspection will be made to the Great Falls (S. C.) stations of the Southern Power Co. and a 100,000-volt sub-station. The official headquarters will be at the Selwyn Hotel.

The Charlotte meeting is not to take the place of the institute's annual convention, which will be held as usual later in the year. The annual dinner will be held at the Hotel Astor in New York City, Feb. 24. Mr. Elihu Thompson, Past-President, who has been awarded the first Edison medal, will be the guest of honor.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Lubrication was the subject under discussion at the meeting held in New York City Jan. 11. Dr. Chas. F. Mabery, Professor of Chemistry at Case School, Cleveland, Ohio, gave an address describing a series of tests on various mixtures of lubricating oils and graphite and on water as a lubricant. A paper on "Efficiency Tests of Lubricating Oils," by Professor Frederick H. Sibley, of the University of Alabama, was presented in abstract by Dr. Chas. E. Lucke, of Columbia University. Gen. Charles Miller, of Franklin, Pa., who was to have addressed the meeting, was unable to be present on account of ill health. His place was taken by Dr. P. H. Connerson, Chief Chemist of the Galena Oil Co., who read a paper setting forth practical considerations governing the choice of a lubricant for particular machines entirely apart from the lubricant's performance under the artificial conditions of the testing machine.

Dr. Mabery's paper was illustrated by a number of curves showing the coefficients of friction of mixtures of Acheson deflocculated graphite with lubricating oils under various conditions of operation. Particularly favorable results were obtained with "oildag," a special oil and graphite mixture prepared by the manufacturers of Acheson graphite. With water as a lubricant, remarkable results were shown in the durability tests made by cutting off the feed of lubricant and continuing to run the bearing until the failure of the lubricant was shown by seizing. For these tests, curves were plotted between lapse of time as abscissas and temperature of bearing as ordinates, the seizing of the bearing being indicated by an abrupt rise of temperature. With the oil and graphite mixtures, the bearing ran for limited periods with gradually rising temperature before seizing took place. With water, the temperature rise was barely perceptible and the bearing ran, apparently for an indefinite time without seizing.

Professor Sibley's paper described tests on 22 different lubricating oils. The tests were made in a journal bearing about 3¼ ins. in diameter and 8 ins. long loaded by means of helical springs with a total load of 1,300 lbs. The same load was used in all tests. The results were recorded in tabular form and in two sets of curves plotted respectively between time and temperature and time and coefficient of friction. In presenting the paper, Dr. Lucke noted that, while the object of the tests was given as the determination of the relation between the viscosity and the wearing and lubricating qualities of the oils, the statement was made near the end of the paper that the tests had revealed no definite relations between viscosity and lubricating qualities. It appeared that the paper's only value lay in the accumulation of data rather than in the presentation of any analysis or conclusions from them.

Mr. William M. Davis, of Boston, Mass., took exception to the general statement in Professor Sibley's paper that a light oil was unsuitable for a heavy load. He told of several actual cases of large and heavily loaded journals where the substitution of a plain mineral oil of much lower viscosity for a compound oil containing 10% of lard oil had resulted in better lubrication and lower bearing temperature. Mr. Henry Souther, of Hartford, Conn., discussed oils for the lubrication of automobile engines. Oils with high flashpoint would seem at first thought to be best suited for use in combustion engines, but they had been found to be too heavy. The main trouble from lubricating oil in automobile engine cylinders was from deposits of carbon residue which became incandescent and caused premature ignition. For use in automobile engines, Mr. Souther would exclude oils giving a carbon residue of as much as one-half of 1%. Mr. Fred R. Low, Editor of "Power," gave the results of inquiries sent out to a large number of engineers as to the quantity of oil used in steam engine cylinder lubrication. The amounts used by different men per sq. in. of cylinder surface rubbed over per second showed large variations. The most extravagant man used 80 times as much as the most economical. Mr. Low estimated that it would cost one of these two men about $14 per year for cylinder oil for a 1,000-HP. plant, while the other would use about $1,120 worth of oil for a plant of the same size.